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Naval Health Research Center

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Summary

Background

The impracticality of measuring maximal oxygen uptake outside of a research laboratory has led to the development of alternative methods of assessing cardiovascular fitness in field settings. The U.S. Navy currently gives sailors a choice between a 1.5-mile run or 500-yard (450 meter) swim as the method of assessing cardiovascular fitness when they take the Navy Physical Readiness Test (PRT) (OPNAVINST 6110.1H). These options may not be suitable for all personnel and are not available in all test settings. Alternative field tests for cardiovascular fitness would be of benefit to the Navy's physical readiness program.

Objective

Performance on an elliptical trainer may provide an alternative field test method for cardiovascular fitness. This report describes research to evaluate the feasibility of using the CT 9500 HR elliptical trainer for PRT testing and to provide standards for its use that were equivalent to current run test standards.

Methods

Study 1: A single test subject exercised for 10 min a cadence of 60 revolutions per minute (rpm) on the CT 9500 HR with resistance set at 8. This exercise bout was repeated on 5 separate machines. The calorie readout was recorded at regular intervals during each exercise bout.

Study 2: Ten active-duty U.S. Navy personnel (8 men, 2 women) performed between 4 and 10 exercise bouts on the CT 9500 HR elliptical trainer. Each bout involved a different combination of resistance and pedal rates. Resistance was set at level 5, 10, or 15. The pedal rate was 50, 60, 70, or 80 rpm. Open-circuit spirometry provided measures of oxygen uptake and the respiratory exchange ratio throughout each bout. The measurements taken over the last 6 min of the exercise bout were used to compute the steady-state aerobic energy consumption rate as an estimate of energy expenditure during the bout. Analyses compared the spirometry-based estimate with the energy expenditure recorded from the CT 9500 HR at the end of the bout.

Study 3: Twenty-three (23) male and 18 female active-duty military personnel completed two 12-minute CT 9500 HR bouts and a 1.5-mile run on alternate days, with a rest day in between. Participants were instructed to do the best they could during each exercise. After one practice session, participants chose the resistance and rpm that they felt would maximize their achievement during the CT 9500 HR bout. The CT 9500 HR energy output was converted to a run time estimate by assuming that the energy cost of running was 1 kilocalorie (kcal) per kilogram (kg) of weight per kilometer (km) of distance. Under this assumption, the energy required to run 1.5 miles is 2.413 times the person's weight in kilograms. The total energy output during the CT 9500 bout was divided by 12 to obtain the energy production rate per minute. The time estimate was the total energy requirement divided by the energy production rate. Analyses related this estimated time to the actual time for a 1.5-mile run that was completed on a standard track on a separate day from the CT 9500 HR bout.

Results

Study 1: The reported energy expenditure increased linearly with time within each bout. Results from different machines were indistinguishable when graphed.

Study 2: The CT 9500 HR and spirometry estimates of energy expenditure demonstrated a strong linear association. However, CT 9500 HR values averaged approximately 34 kcal higher than the spirometry values.

Study 3: The relationship between estimated and actual run times was strong and linear. However, as would be expected if the CT 9500 HR overestimated energy expenditure, the average predicted time was 1:33 min faster than the average actual time. Follow-up analyses compared different methods of correcting for the apparent bias in CT 9500 HR energy expenditure values. The best approach to correction was to add 1:08 min to the time estimates for men and 2:15 min to the time estimates for women. The standard error of the resulting predictions was 0:57 min.

Conclusion

CT 9500 HR performance can yield valid and accurate estimates of 1.5-mile run times. Study 1 showed that different machines were interchangeable, so the use of different machines at different sites should not be a problem. Study 2 showed that the CT 9500 HR energy expenditure readout is valid in the sense that it is strongly related to accepted laboratory measures of energy expenditure. However, Study 2 also indicated that CT 9500 HR energy expenditure values were consistently higher than the values obtained from spirometry. This combination of validity and bias also was evident in Study 3. Estimated run times based on CT 9500 HR energy expenditure showed a strong linear relationship to actual run time. However, the estimates consistently were too fast as would be expected if the CT 9500 HR energy values were biased upward. The bias could be corrected by adding a constant to estimated run times. The standard error of 0:57 min for the adjusted estimates of run time is identical to the standard error obtained when laboratory assessments of maximal oxygen uptake capacity are used to predict 1.5-mile run times. Thus, the adjusted time estimates for the CT 9500 HR had state-of-the-art accuracy. CT 9500 HR energy expenditure therefore provides a valid measure of cardiovascular fitness. The appendices to this report provide tables that equate CT 9500 HR energy expenditure with existing run time standards.

Introduction

Although direct measurement of maximal oxygen consumption (VO_{2max}) is the standard for assessing cardiovascular fitness, the impracticality of performing measurements of VO_{2max} in a field environment has led to the development of many predictive tests as an indirect measurement of fitness. The U.S. Navy currently uses two types of field test, a 1.5-mile run or 500-yard (450 meter) swim to assess cardiovascular fitness in the Navy Physical Readiness Test (PRT) as described in the physical readiness program (OPNAVINST 6110.1H). Due to chronic orthopedic injury, members are often waived from the cardiovascular portion of the assessment. Individuals waived from the run are not required to participate in the swim because of the skill involved in swimming. Alternative cardiovascular tests that can be performed by individuals unable to run would be of benefit to the Navy's physical readiness program.

Tests on an elliptical trainer may be a suitable alternative low-impact assessment of cardiovascular fitness. Studies have demonstrated that individuals working out on elliptical trainers experience ground reaction forces similar to walking (110% of total body weight) but at heart rate and oxygen consumption values similar to those experienced during running (which has ground reaction forces equal to 250% of total body weight) (Porcari, Foster, & Schneider, 2000; Porcari, Zedaker, Naser, & Miller, 2000). Additionally, alternative cardiovascular assessments should have an exertion level similar to the 1.5-mile run. Evaluations of a competitor brand of elliptical trainer have demonstrated caloric expenditures and ratings of perceived exertion (RPE) similar to those measured during treadmill running (Clay, 2000; Kravitz, Mayo, & Alvarez, 2002; Mercer, Dufek, & Bates, 2001; Spranger, 1998).) When overweight exercise participants were asked to select an intensity based upon an RPE value on the elliptical trainer, oxygen uptake (VO_2,) energy expenditure, and heart rate all exceeded that of exercise at the same RPE on the treadmill (Kim, 1998). These findings suggest that exercise intensity may actually be greater on the elliptical trainer than the treadmill.

Another practical consideration for Navy personnel is that deployment schedules for afloat commands may hamper individuals' ability to adhere to a regular running or swimming program. Elliptical trainers are currently available on many ships, allowing sailors to maintain an exercise schedule even when deployed. The CT 9500 HR is powered completely by movement and may be placed anywhere in a facility because electrical cords and outlets are not necessary. This makes these machines ideal for afloat commands. The U.S. Navy Morale, Welfare, and Recreation has purchased the CT 9500 HR rear-drive model elliptical trainer for placement in Navy gyms and ships. Despite the availability of the CT 9500 HR elliptical trainer for Navy service members, it has not been evaluated as an alternate method to assess cardiovascular fitness in the PRT.

The CT 9500 HR rear-drive model elliptical trainer calculates and displays total caloric expenditure and distance for each workout session. Distance is a function of the force phase of the ellipse (pushing down with one's foot) times the rpm over a period of time, while the caloric estimation algorithm is a function of weight times resistance times rpm (personal communication between the senior author and LifeFitness™ technical support personnel, February, 2003). The actual calculations are not available due to an impending patent application. In two productions of the CT 9500 HR model, the software for the distance calculation has been upgraded, resulting in potentially different distance estimates between trainers. Additionally, since distance is a calculated effect over time it is only displayed periodically and may not be available at the end of the exercise or provide frequent enough performance feedback to the participant to be the basis for organizing a performance test. Due to the difficulties of utilizing distance as a final output marker, total caloric expenditure will be the performance measure. Bout duration will be 12 min to make the exercise bout similar to Cooper's 12-minute run test (Cooper, 1968).

This report addresses issues associated with the use of the CT 9500 HR for fitness testing. First, are different machines of the CT 9500 HR model equivalent? If not, test results will depend on which machine is used in a test session. Second, is the energy expenditure estimate accurate? Inaccuracies may make it impossible to translate CT 9500 HR measures into run times. Third, what is the relationship of CT 9500 HR performance to 1.5-mile run performance? This question is important because the 1.5-mile run is the logical reference point for equating CT 9500 HR performance to current test procedures.

Study 1
Intermachine Consistency and Caloric Expenditure Validity

CT 9500 HR machines must be interchangeable. An initial study (n = 1) compared 5 different CT 9500 HR rear-drive machines. The single subject in this study completed a series of exercise bouts with the machines set at a resistance of 8, entering the same body weight each time. Running speed was 60 rpm throughout the bout. The cumulative energy expenditure was recorded at regular intervals during a 10-min exercise session.

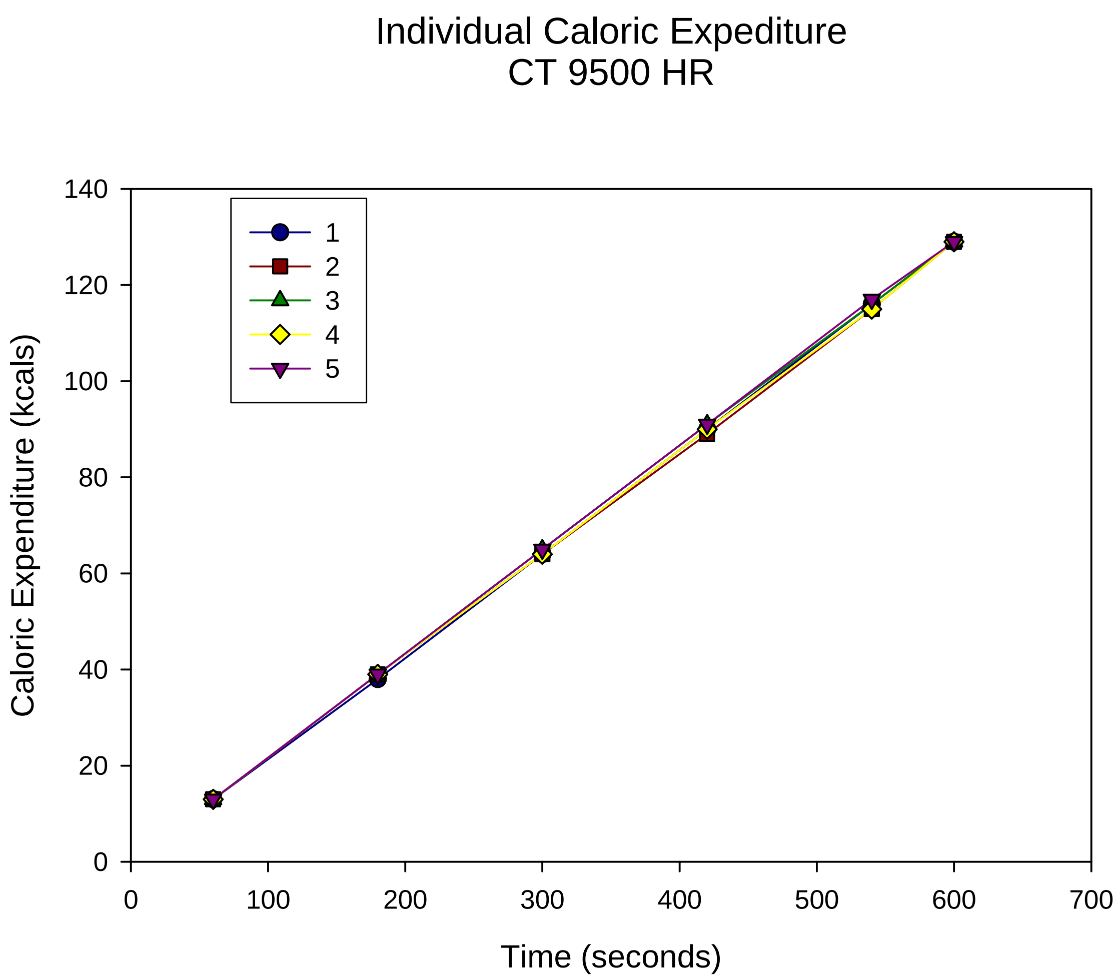

Figure 1. Individual caloric expenditure on 5 machines at 60 rpm, resistance level 8.

The caloric output reported over the course of the 5 bouts was virtually identical for all machines (Figure 1). The slight differences in output were much smaller than the clear differences in cumulative output over time.

Discussion

The 5 machines were interchangeable. Even small differences in average rpm during the bouts could explain the observed differences in energy expenditure shown in Figure 1. Good engineering combined with a good quality control during the production of CT 9500 HR is a reasonable explanation for these findings. Assuming these factors are the basis for the observed intermachine equivalence, the present findings can be expected to generalize to other machines.

Two qualifications to the present conclusion are noteworthy. First, the evidence is limited to a single resistance/rpm combination. The next study addressed this potential limitation. Second, the wear and tear of normal use could cause machines to develop differences over time. Test administration should include procedures to verify machine equivalence before testing. This study illustrates one approach to verification.

Study 2
Accuracy of Energy Expenditure Values

A fair CT 9500 HR test will allow test subjects to choose a comfortable workload and running pace. Allowing these choices is no problem if the CT 9500 HR is accurate over different combinations of resistance and rpm. Determining whether the CT 9500 HR satisfied this requirement was the primary goal of Study 2. Accuracy was quantified by comparing the energy expenditure reported by the CT 9500 HR (EE_{CT}) to a laboratory standard. The laboratory standard was provided by computing an energy expenditure estimate from oxygen uptake measured by open-circuit spirometry (EE_{O2}).

Methods

Subjects

Ten (10) active-duty U.S. Navy personnel, 8 men and 2 women stationed in San Diego County, participated in this study. All subjects were in good general health, had no chronic medical problems, were not under a current medical waiver for participation in the PRT, and were not on any chronic medications (steroid inhalants or steroids, anti-inflammatory drugs). One individual was taking a beta blocker. Subjects were recruited in three ways: (1) advertising in the local “Items of Interest” message (released weekly by Commander, Naval Region Southwest) to recruit from the general Navy population; (2) posting flyers in area gyms to recruit sailors who have experience using the elliptical trainer; and (3) contacting area Command Fitness Leaders in order to recruit sailors who have trouble meeting body composition standards. The Institutional Review Board at the Naval Health Research Center approved all recruitment and experimental procedures before the study began. As part of the approved procedures, all subjects provided informed consent and completed a medical history screening questionnaire prior to testing.

Anthropometric Measurements

Stature and body circumferences (neck and abdomen for men; neck, waist, and hips for women) were measured on all participants with a tape measure. The U.S. Navy equations in

OPNAVINST 6110.1H converted circumferences to estimated percent body fat (Hodgdon & Beckett, 1984a, 1984b).

Exercise Bouts

Each exercise bout was a session on a CT 9500 HR. The participant was weighed before each bout while wearing the equipment used to measure oxygen uptake. The total weight was entered into the CT 9500 HR. Total weight was used to allow for the energy required to carry the equipment during the exercise.

A duration of 15 min and a warm-up resistance level of three was entered into the equipment before the exercise began. Two minutes were for warm-up. The next 12 min comprised the actual exercise bout. A final minute was added to the bout to ensure that the final energy expenditure could be recorded before the machine reverted to “cool down” mode.

Participants performed the 2-min warm-up at the resistance level described above and a stride rate of 50 rpm. After 2 min, the investigator increased the resistance to the predetermined level for the bout. The participant then ran at that level for 12 min. Participants were instructed to maintain their stride rate at the preselected level set by the investigators. Investigators monitored compliance with the pace requirement throughout the test. Participants were required to grasp the moving handlebars for the duration of the bout. This requirement prevented them from leaning on the stationary handlebars to support their weight.

Each participant volunteered to complete the set of 10 exercise bouts shown in Table 1. Up to 4 exercise bouts in the sequence were completed in each data collection session. The bouts were completed in a modified random order for each participant. The order was modified by placing the bout requiring the lowest work output first in each session. The modification minimized cumulative fatigue for later bouts. Participants rested a minimum of 15 min between bouts. During that time, participants were encouraged to drink as much water as they wished.

Table 1. Exercise Configurations for the Elliptical Trainer Test Sessions

	RPM				
		50	60	70	80
Resistance	5		X	X	X
	10	X	X	X	X
	15	X	X	X	

Three participants (2 male, 1 female) completed all 10 bouts. For other participants, some of the exercise bouts were stopped when the individual failed to maintain the required rpm or reached volitional fatigue. Other bouts never began because the participant chose not to attempt them. These decisions reflected the participant’s belief that the required work exceeded his or her capability. This judgment was usually based on the participant’s failure to complete earlier bouts at lower resistance or rpm rate.

CT9500 HR Energy Expenditure Estimates

The CT 9500 HR provided a running estimate of the energy expended during each exercise bout. This estimate, EE_{CT}, is displayed on the machine during exercise. The machine updates the estimate each time the computational algorithm indicates that 1 additional kilocalorie of energy has been expended. Researchers recorded the kilocalorie readout from the machine manually at 30-sec intervals. At the completion of the 12-min exercise bout, the researcher immediately pressed the “Clear” button twice, while the participant continued to pedal at a lower stride rate. This procedure allowed the researchers time to record the final machine read-out for cumulative caloric expenditure. Immediately stopping the exercise would have resulted in loss of final data, because these machines are driven by movement and not electricity.

Oxygen Consumption Measurements

Oxygen consumption and respiratory exchange ratio (RER) were recorded breath-by-breath during each exercise bout. The measures were provided by a standard, commercially available open-circuit spirometry system (SensorMedics System 2900, Yorba Linda, CA). Prior to the bouts, participants were fitted with a face mask, which was used with the open-circuit spirometry system, and weighed. The combined weight of the study participant’s body and the mask weight were used to compute energy expenditure. This combined weight was appropriate because it was the total weight that had to be moved during exercise.

Energy Expenditure Computations for Oxygen Consumption

Measured oxygen uptake was converted to the energy expenditure estimate, EE_{O2}. Steady-state oxygen uptake was the average value over the last 6 min of each bout. Preliminary analyses established that oxygen uptake was sufficiently constant over this period to treat the average value as an index of steady-state uptake (Appendix A). An average RER was computed for the same period. RER was needed because the caloric yield from consuming a milliliter of oxygen depends on the mixture of fats and carbohydrates being burned. RER is an indicator of the relative proportions (McArdle, Katch, & Katch, 2001). Analysis of the RER conversion values given in Table 8.1 of McArdle et al. (2001) produced the equation:

$$EE_{O2} = VO_2 * [3.816 + (1.231 * RER)] \quad \text{(Equation 1)}$$

Equation 1 converts oxygen consumption in liters to energy output in $kcal \cdot min^{-1}$. The cumulative EE_{O2} for the bout was obtained by extrapolating from the average EE_{O2} for the last 6 min. During this time period, aerobic processes should have provided nearly all of the required energy. The energy requirement itself, which was determined by weight, resistance, and stride rate, was constant over the full bout. The average steady-state energy expenditure per minute therefore could be multiplied by 12 to obtain an index of the total energy expended during the bout. This total includes anaerobic energy used during the initial part of each bout. Anaerobic energy is needed initially because aerobic processes take time to activate (McArdle et al., 2001). EE_{CT} represented energy expended over the full 12-min bout.

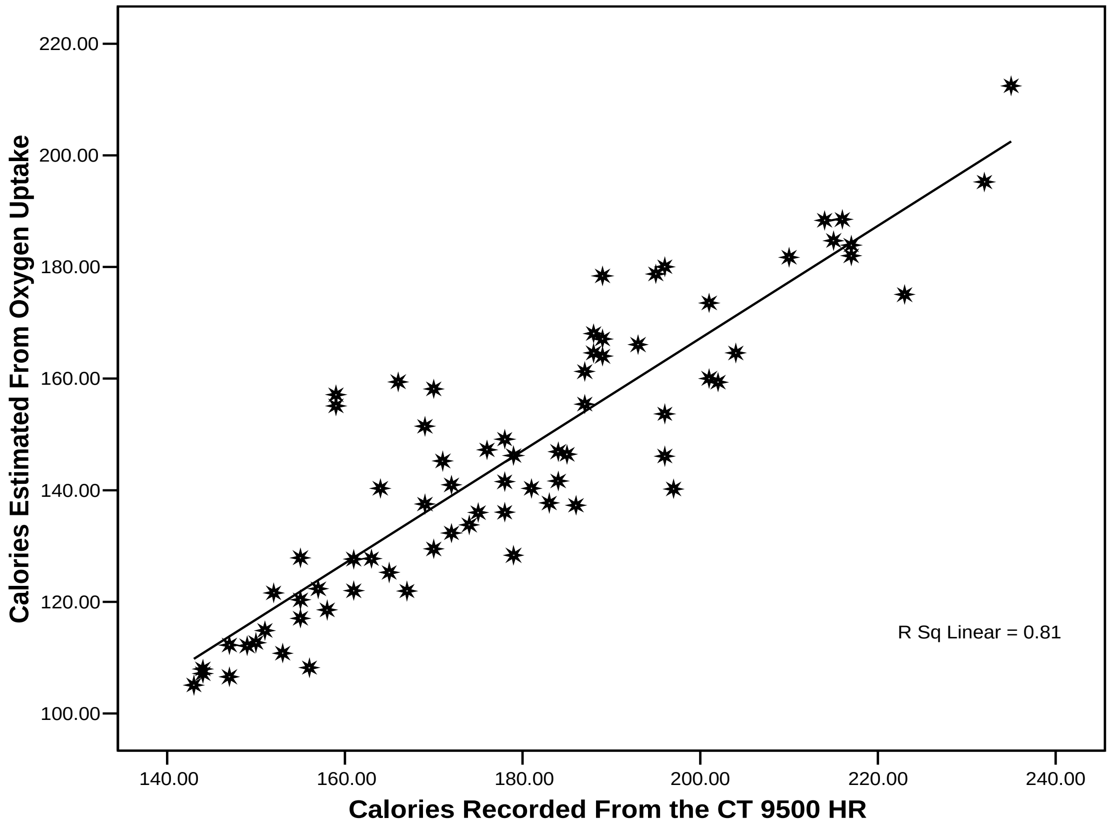

Figure 2. Relationship of measured and reported energy expenditure.

Analysis Procedures

The regression analysis and generalized linear model (GLM) procedures of SPSS-PC (SPSS, Inc., 1998a, 1998b) were used to perform the primary analyses. A hierarchical linear model (HLM) analysis was performed with HLM 6 (Raudenbush, Bryk, Cheong, & Congdon, 2004).

Results

A linear relationship of EE_{O2} with EE_{CT} was evident in the data (Figure 2). However, the line relating the two measures would not pass through zero. On average, EE_{CT} was 32.95 kcal·min^{-1} higher than EE_{O2}. This difference was highly significant statistically, t (1, 72) = 25.38, $p < .001$. The regression of EE_{O2} on EE_{CT} indicated that the two estimates corresponded well after allowing for this trend:

$$EE_{O2}' = 1.008 * EE_{CT} - 34.370 \quad \text{(Equation 2)}$$

In this equation, EE_{O2}' is the predicted value for EE_{O2}. Equation 1 accounted for 81% of the EE_{O2} variance. The standard error of estimate (SEE) was 11.09 kcal. The 95% confidence interval (95% CI) for the slope was (0.894, 1.122). The 95% CI for the intercept was (-55.00, -13.74). These CIs indicated that the slope and intercept differed significantly ($p < .05$) from zero.

However, the fact that the confidence interval for the slope included 1.000 is more important than the fact that the slope was greater than zero. This second point indicated that the sample estimate did not differ significantly from the ideal 1:1 correspondence after allowing for the apparent bias in EE_{CT}.

Additional analyses described in Appendix B produced 2 models as alternatives to Equation 2. One alternative was based on analyses to identify factors that might be sources of bias when Equation 2 was used to estimate energy expenditure. The analyses indicated that the accuracy of prediction was improved by adding adjustments for resistance level and body weight. The resulting model was

$$EE_{O2}' = (1.087*EE_{CT}) + (.273*\text{Weight}) - (11.292*\text{Level Dichotomy}) - 49.979 \quad \text{(Equation 3)}$$

The model represented by Equation 3 treated resistance level as a dichotomy contrasting level 5 with levels 10 and 15 combined (cf., Appendix B gives the statistical basis for this decision). Given $R^2 = .857$ for Equation 3, the bias adjustments accounted for 4.7% of the variance in EE_{O2}. Adding the adjustments resulted in a decrease in SEE from 11.09 kcal in Equation 2 to 9.75 kcal in Equation 3. The EE_{CT} regression coefficient increased from 1.008 to 1.087, but the 95% CI (.973, 1.201) still included 1.00.

A second alternative to Equation 2 was generated by considering the effect of constraining participants' options during testing. When the analysis was limited to bouts involving resistances of 10 or 15, the model was

$$EE_{O2} = 1.075*EE_{CT} - 49.958 \quad \text{(Equation 4)}$$

This model was substantially more accurate than the one in Equation 3. The proportion of EE_{O2} variance explained by the model increased from 81.0% to 88.9%. SEE decreased from the 9.75 kcal (Equation 1) to 8.91 kcal.

The EE_{CT} regression coefficient (1.075) for Equation 4 was larger than that in Equation 2 (1.008) and smaller than that in Equation 3 (1.087). However, the 95% CI for the Equation 4 estimate was (.965, 1.185). This range encompassed both of the earlier estimates and 1.000.

Weight was not significantly related to EE_{O2} after imposing the resistance constraint, $b = .15$, $SE_b = .157$, $t\,(1, 46) = .953$, $p > .345$. Deleting this predictor actually resulted in a smaller SEE for Equation 4 than for Equation 3 (SEE = 8.92 vs. 8.91).[1]

Discussion

EE_{CT} was higher than EE_{O2}. The average difference was 33 kcal. This difference was equally clear at the level of individual bouts. EE_{CT} was higher than EE_{O2} for 72 of 73 bouts. However, EE_{CT} was a strong predictor of EE_{O2} despite this bias. In fact, the data did not rule out a 1:1 relationship of EE_{CT} with EE_{O2} after allowing for the higher average value of EE_{CT}. The

[1]SEE increased because the *t* value for weight was <1.00. This result indicated that the degree of freedom used to estimate the regression coefficient for weight accounted for less than the average amount of error variance. When a value that is less than the current average for a set of data points is added to the set, the average for the revised set must be lower.

slopes of the regression of EE_{O2} on EE_{CT} in Equations 2 through 4 ranged from 1.008 to 1.087, but the 95% CI included 1.000 in each case.[2]

Characteristics of the test bout or test subject had little effect on the correspondence of EE_{CT} and EE_{O2}. These factors accounted for at most 4.7% of the total EE_{O2} variance in EE_{O2}. This explanatory power was linked primarily to resistance level, which accounted for 3.3% of the EE_{O2} variance. The resistance effect reduced to a contrast of level 5 with levels 10 and 15 (cf., Appendix B). This contrast accounted for 3.2% of the EE_{O2} variance, so treating levels 10 and 15 as equivalent meant only a 0.1% reduction in variance explained. If tests were restricted to resistances of 10 or greater, the bias in EE_{CT} would increase to ~50 kcal, but the EE_{O2} estimates would be more accurate (8.91 kcal vs. 9.75 kcal) after allowing for this bias.

The general conclusion from comparing EE_{CT} and EE_{O2} was that EE_{CT} was an accurate, but biased estimate of energy expenditure. This most important aspect of this finding is it implies that converting raw EE_{CT} values to estimated run times will produce time estimates that are too fast. The third study examined this point in greater detail.

Study 3
Predicting Run Times

CT 9500 HR performance must be equated with running performance to set fair PRT standards for this new testing method. Run test performance is the reference standard because the large majority of sailors currently receive PRT scores derived from the 1.5-mile run. Matching CT 9500 HR performance to run test performance will maximize the consistency of test standards for the general U.S. Navy population.

The fact that running performance has been extensively validated against laboratory measures of maximal oxygen uptake (VO_{2max}) is another reason for matching CT 9500 HR performance and 1.5-mile run performance. The validity of distance runs as predictors of VO_{2max} is well established (Vickers, 2001a, 2001b, 2002). The typical correlation is between $r = .85$ and $r = .90$. Given the strength of this association, any other test that is strongly related to running must have at least a moderate correlation to maximal oxygen uptake capacity. Thus, a strong association between EE_{CT} and 1.5-mile run time would be further evidence of the validity of EE_{CT}.

In theory, EE_{CT} could be converted directly into an estimate of run time. The procedure would be based on evidence that running a given distance requires a fixed amount of energy that is independent of running speed (McArdle et al., 2001).[3] Taking this as a point of departure, EE_{CT} could be converted to run time as follows:

Step 1 – Compute total energy requirement: ER (in kcal) = 2.413*Weight (in kg)
Step 2 – Compute energy expenditure rate (EE_r): $EE_r = EE_{CT}/\text{time} = EE/12$

[2] Supplementary analyses were conducted to determine whether this slope differed from one individual to another. The GLM analysis of covariance (ANCOVA) and the HLM analyses described in Appendix B indicated that there were no individual differences in slope and that the best overall estimate slope was 1.020. The data, therefore, were consistent with a slope of 1.000 that would apply to all individuals.

[3] Energy cost actually increases with running speed because of greater air resistance. However, the effect is negligible at the speeds typical of endurance runs (di Prampero, 1986). It is therefore common practice to treat speed and energy cost as independent for endurance runs.

Step 3 – Compute run time: $T = ER/EE_r$

The computations assume that the energy cost of running is 1 $kcal \cdot kg^{-1} \cdot km^{-1}$ and that the cost is independent of speed. These assumptions are generally accepted as reasonable for speeds typical of a 1.5-mile run (di Prampero, 1986; McArdle et al., 2001). EE_{CT} is divided by 12 to obtain an energy expenditure in $kcal \cdot min^{-1}$. Dividing the total requirement by the rate at which energy is being expended provides an indication of the time that will be required to generate the energy required to run the required distance.

The above computations would accurately estimate run time if EE_{CT} were an unbiased measure of energy expenditure. If EE_{CT} overestimates energy expenditure, as suggested by Study 2, the above computations will underestimate run time. This prediction follows from the fact that the denominator in Step 3 will be too large. The numerator will remain the same, so using the inflated EE_r will yield times that are faster than should really be expected. Clearly allowing this bias to remain in the computations would introduce inequities into the PRT system if some sailors were tested on the CT 9500 HR while others ran.

The third study examined the relationship of run time estimates based on the three-step procedure described in this introduction with actual run time. One goal was to verify that estimated run times were faster than actual run times. This verification would provide independent evidence that EE_{CT} truly overestimates EE_{O2}. A second goal was to provide some method of correcting for the bias.

Methods

Sample

Women (n = 18) and men (n = 23) were recruited from military commands in the San Diego area. The recruitment, consent, and screening procedures were the same as those in Study 2 with one modification. Three participants were taking medicine to control blood cholesterol levels; 2 participants were taking medicine to control blood pressure. The original study design called for a stratified sampling procedure. The goal was to recruit 3 male and 3 female participants from each of 9 age categories. Early in the recruitment process, some volunteers were turned away because their age category already was filled. This constraint was removed later in the recruitment process when it became evident that the 18–20 and 45 and older age groups would be very hard to fill. Removing the constraint allowed the project to proceed in a timely fashion with an acceptable sample size. Exercise bouts were assigned in randomized fashion.

CT 9500 HR Procedures

Participants performed two CT 9500 HR exercise bouts. Both bouts were 12-min long. During a familiarization bout, a 2-min warm-up at resistance level 3 at 50 rpm was followed by increases in resistance and speed until the participant felt the exertion approximated his or her typical effort during the 1.5-mile run test. The participant then exercised until the bout time limit was reached.

The second bout began with a 2-minute warm-up, after which the resistance was set at the value chosen following the familiarization bout. The participant then completed the 12-minute exercise bout, varying his or her running pace as required to maximize performance. Heart rate and EE_{CT} were recorded at 30-sec intervals during the bout. Participants selected their own resistance level and then adjusted their rpm to equal the effort they put into the 1.5-mile run.

1.5-mile Run Procedures

The 1.5-mile run was held at two measured courses (Marine Corps Recruit Depot and Fleet Training Center Pacific, San Diego). Participants were instructed to warm up with a 2-min jog at a self-selected pace. Heart rate was recorded at 30-sec intervals as well as final run time.

Analysis Procedures

The three-step procedure described in the introduction to this study provided one set of run time estimates. The *t*-test for correlated observations was used to evaluate the hypothesis that the resulting run time estimates would be faster than the actual run times. Regression and GLM procedures provided linear models based on gender, age, and EE_{CT}. These procedures were implemented using the SPSS-PC computer program.

Results

Choice of Exercise Bouts

The study participants were free to choose their exercise intensity. Once the intensity was chosen on the second elliptical bout it could not be changed. Participants could set their own stride rate and vary it as they wished. Analysis of these choices indicated that:

- Resistance choices ranged from 4 to 17, with a mean of 11.51. Most participants chose a resistance in the 10 to 15 range, but 11 chose a resistance ≤9, while 5 chose values >15.

- The average stride rate maintained over the course of the bout ranged from 49.50 rpm to 88.95 rpm. The mean of these average stride rates was 68.1 rpm, with 1 participant below 50 rpm and 2 participants above 80 rpm.

- Participants who chose higher resistance levels also tended to choose a higher rpm (r = .422, $p < .003$).

Test of the Analytic Energy Expenditure-to-Run Time Conversion Procedure

As expected, the predicted run times based on raw EE_{CT} were too fast. The average predicted time of 10:52 min (SD = 2:07) was 1:33 faster than the average actual run time of 12:25 min (SD = 2:27). The difference was highly statistically significant, $t\,(1,40) = -8.09$, $p < .001$.

A Run Time Prediction Model

Figure 3 displays the basic relationship between run time and predicted time, T. Several important trends in the data are clearly evident:

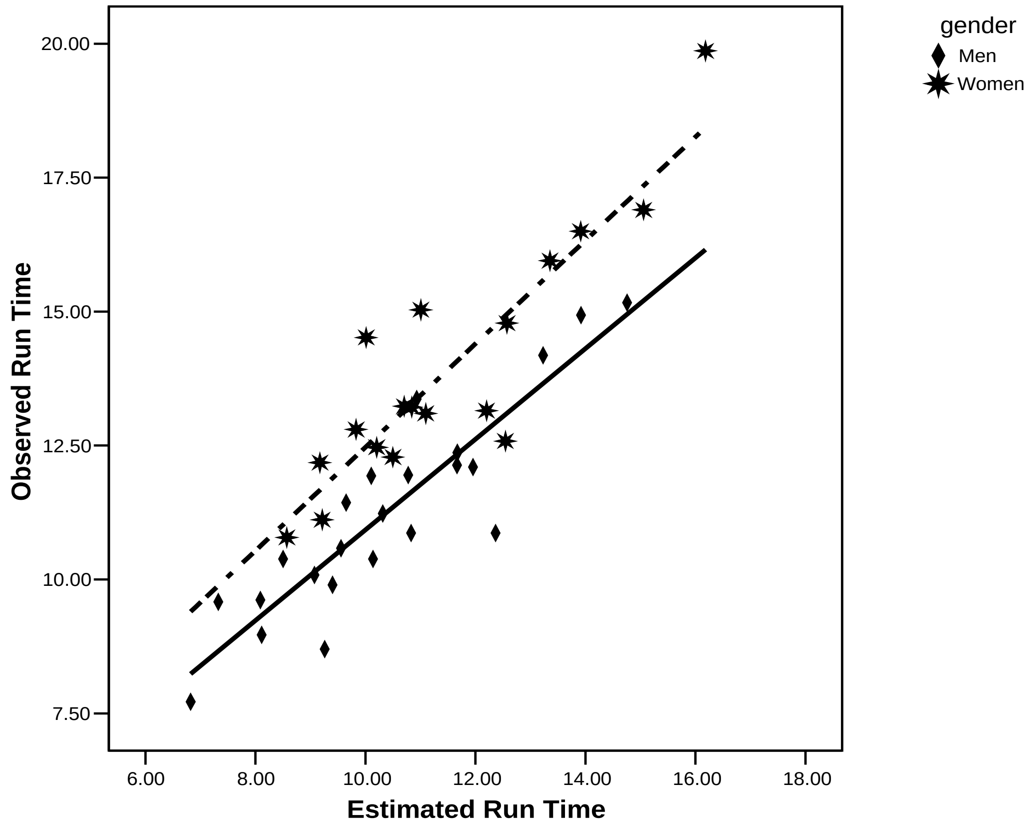

Figure 3. Relationship of analytic run time predictions and observed run times.

- Predicted time was linearly related to actual time.
- The regression lines for men and women were roughly parallel.
- The line for women was higher than that for men.
- Predicted times were faster than actual times for both men and women.
- The linear model was accurate for men (R^2 = .810) and women (R^2 = .792)

An extensive series of analyses that compared alternative models as statistical representations of the data in Figure 3 indicated that separate equations were appropriate for men and women (cf., Appendix C). The best method for converting EE_{CT} to run time was to employ the three-step procedure described in the introduction to this study to generate an initial prediction of the run time, T, and then make a gender-specific adjustment to that prediction. The analyses resulted in the following general equation:

$$t' = T + 1{:}08 \qquad \text{(Equation 5)}$$

Equation 5 produces the following gender-specific equations when the coded values for gender (i.e., Male = 1, Female = 2) are entered into this equation:

Men: t' = T + 1:08 (Equation 6)

Women: t' = T + 2:15[4] (Equation 7)

Age Effects

Current PRT standards include age adjustments, so age effects must be considered when an alternative test is used in place of the 1.5-mile run. Adding age to the predictive model for run times increased the variance explained by only 0.2%, $F\ (1, 36) = 0.37$, $p > .548$.

Discussion

Predicted times based on the three-step procedure described in the introduction to this study were too fast. This trend was expected given prior evidence that EE_{CT} overestimated energy expenditure. Data analysis therefore emphasized the development of an appropriate method of correcting for this bias. The best method of adjustment was to add a constant to the predicted times. The constant was 1:08 min for men and 2:15 min for women. These adjustments should be accurate to within ±0:13 min even though they were derived from a relatively small sample (cf., Appendix C).

The time estimates do not have to be corrected for age. This result may appear to be at odds with the general tendency for performance on physical tasks to diminish with age. However, age could reasonably be expected to affect the performance on both tests. Age apparently does not affect the relationship between the two types of performance. However, the age effects built into the current run test performance standards mean still will affect PRT standards for CT 9500 HR performance. Performance standards will decrease with age because the run test standards that define the reference points for the CT 9500 HR standards diminish with age.

The equations for translating EE_{CT} into estimated run times are accurate. Equation 5, which accounted for 84.3% of the variance in run times, produced an SEE of 0:57 min. The 95% CI for predicting individual run times therefore is ±1:47 min. This range of uncertainty appears large, but it should be viewed in proper context. Laboratory VO_{2max}, the gold standard for assessing cardiovascular fitness, is a highly valid predictor of endurance run times (Vickers, 2001a, 2001b, 2002). The error associated with using this reference standard to predict 1.5-mile run times is 0:57 min.[5] Thus, the linear model based on EE_{CT} and gender is as accurate as the best available alternative test.

The predictive accuracy of the linear models in Equations 6 and 7 is underscored by viewing the predictions from a different perspective. Test results often are converted to dichotomies. "Pass–fail" is one example; "outstanding–less than outstanding" is another. The EE_{CT}–run time correlations can be converted to estimates of the proportion of times that EE_{CT} results would correctly classify the individual if run time were converted to this type of

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[4] The constant in Equation 5 was a rounded value. The extended value was 1:07.56 min. When this figure is used to compute the gender-specific equations, the constant for females is 2:15 min rather than the value of 2:16 that would be obtained by multiplying the Equation 5 constant by 2.

[5] This value is based on the analysis of 14 studies ($\sum N = 509$) of VO_{2max} as a predictor of 1.5-mile run time (Vickers, in preparation).

dichotomous classification (Rosenthal & Rubin, 1982).[6] From this perspective, the validity coefficients for men (r = .900) and women (r = .837) convert to agreement rates of 95% and 92%, respectively. Once again, a comparison of the current method with laboratory measures of VO_{2max} provides context for interpreting this convergence. The correlation between VO_{2max} and 1.5-mile run times is r = .800 for an agreement rate of 90%.[7] This figure is less than the expected validity of the EE_{CT} classification for both men and women. In fact, the strongest reported correlation of VO_{2max} with 1.5-mile run time is r = .91 (Getchell, Kirkendall, & Robbins, 1977) for an agreement rate of 95.5%.

In summary, run time predictions obtained by simply converting EE_{CT} results into run time estimates were faster than the observed run times. This finding was expected given prior evidence that EE_{CT} overestimates true energy expenditure. These systematic errors can be eliminated by adding 1:08 min to the predicted times for men and 2:15 min to the predicted times for women. The resulting run time estimates are as accurate as those obtained with laboratory tests of maximal oxygen uptake. The time adjustment approach therefore provided a simple method of converting EE_{CT} to run time with state-of-the-art accuracy.

Test Standards for Elliptical Trainer Exercise

Run times can be converted into age-group standards. EE_{CT} standards are more complex because energy requirements depend on the weight of the runner. Table 1 on the following page shows the standards appropriate for a 175-pound man. Table entries are the EE_{CT} values for which predicted run times would equal the run time standards specified in OPNAVINST 6110.1H for each age group.

The EE_{CT} standards change irregularly across performance levels and age groups. Several factors contribute to the irregularity. First, the time intervals that define different categories vary in size within each age group. Second, age allowances for the run test are greater for some age groups than others. Third, run time is inversely related to energy production. The pattern of differences in Table 1 would be more regular if time intervals were equal across performance levels, age adjustments were the same for all adjacent age groups, and the energy production–run time relationship was linear.

Despite irregularities, the EE_{CT} values in Table 1 do illustrate general patterns of change in the EE_{CT} performance requirements as a function of performance level and age. The difference between “Probationary” and “Outstanding High” is ~10 kcal per minute in the youngest age group. The difference is ~8 kcal per minute (i.e., 95 to 100 kcal) for the two oldest age groups. Age differences are ~2.2 kcal per year for the “Outstanding High” category compared with ~1.6 kcal per year for the “Probationary” category. Because each figure applies to a 12-min exercise bout, even minor differences in the actual energy expenditure rate will modify the performance

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[6] This statement is literally true only when the criterion splits the population into 2 groups of equal size. However, the error is small even for splits as extreme as 5% and 95% (Rosenthal & Rubin, 1982).

[7] This value is based on the analysis of 22 studies ($\sum N = 811$) of VO_{2max} as a predictor of 1.5-mile run time (Vickers, in preparation). Rasch (1974) was excluded from the data based on outlier status arising from low validity (r = .259, N = 22; z = -3.56). The estimated association would be only slightly affected by including this case (r = .794). The average must be treated cautiously. The estimates varied significantly from sample to sample (with outlier, $\chi^2 = 57.88$, 21 df, $p < .001$; without outlier, $\chi^2 = 44.89$, 21 df, $p <$ .002).

Table 1. Examples of Elliptical Trainer Performance Standards: Standards for a 175-lb Male

	Performance Classification											
Age	O/H	O/M	O/L	E/H	E/M	E/L	G/H	G/M	G/L	S/H	S/M	Pro.
17-19	322.6	301.4	291.9	282.9	274.4	266.5	259.0	245.1	232.7	211.3	206.6	202.0
20-24	311.6	291.9	282.9	266.5	259.0	245.1	238.8	221.5	211.3	197.7	189.5	185.7
25-29	295.0	278.3	270.1	251.9	245.1	235.9	224.0	206.6	195.5	187.5	182.0	178.5
30-34	280.0	266.5	259.0	245.1	232.7	227.0	211.3	193.5	182.0	178.5	175.1	171.8
35-39	277.2	262.4	255.1	241.7	229.6	224.0	204.1	187.5	176.7	173.3	168.7	165.6
40-44	274.4	259.0	251.9	238.8	227.0	216.3	197.7	182.0	171.8	168.7	162.7	159.9
45-49	272.8	255.1	245.1	229.6	218.7	208.8	193.5	176.7	167.0	162.7	157.1	153.1
50-54	271.7	251.9	246.5	221.5	211.3	202.0	189.5	171.8	162.7	157.1	151.9	147.1
55-59	240.0	229.3	223.3	212.3	202.3	190.3	175.5	162.9	151.9	149.0	146.1	143.4
60-64	224.8	215.3	210.0	199.1	189.3	180.1	165.6	153.3	142.7	138.0	133.5	129.7
65+	217.7	207.2	198.3	188.3	179.2	171.0	156.8	144.8	134.5	128.6	123.2	118.1

Note. The performance standards have been labeled as follows: O = Outstanding, E = Excellent, G = Good, S = Satisfactory, H = High, M = Medium, and L = Low. “O/H” therefore is the “Outstanding High” category. “Pro” is the energy output that must be achieved to be classified as “Probationary” under the OPNAVINST 6110.1H standards.

classification. However, the same is true of minor differences in the rate of energy expenditure for a run test.

A variant of Table 1 can be constructed for any combination of gender and weight. Appendix D provides the full set of values for each age category for men weighing between 90 and 300 pounds. Appendix E provides the same information for women.

General Summary

This report has presented research that evaluated the potential use of an elliptical trainer as a cardiovascular fitness test. The elliptical trainer would provide a low-impact assessment of cardiovascular fitness as an option in the U.S. Navy PRT. An initial study demonstrated that different CT 9500 HR machines produced virtually identical cumulative energy expenditure estimates during equivalent exercise bouts. A second study showed that the relationship of energy expenditure reported by the CT 9500 HR with open-circuit spirometry was virtually 1:1 after allowing for an upward bias of ~2.9 $kcal \cdot min^{-1}$ in the CT 9500 HR values. The third study in the series provided additional evidence of this bias. Time estimates based on CT 9500 HR energy expenditure had a strong linear relationship to actual run time. However, the estimates were consistently faster than the actual times. This tendency was corrected by adding a constant to the estimated time. The constant was larger for women (2:15 min) than for men (1:08). With this adjustment, the time estimates were as accurate as those obtained with laboratory measures of $VO2_{max}$, the accepted reference standard for evaluating cardiovascular fitness. Taken together these studies demonstrated that CT 9500 HR performance is a valid fitness index by two criteria. First, CT 9500 HR performance has an appropriate relationship to the relevant aspect of physiological functioning. Second, CT 9500 HR performance is appropriately related to performance on the run test that most sailors take to assess cardiovascular fitness in the PRT. The functional relationships of CT 9500 HR energy expenditure with these criteria indicate that CT 9500 HR energy expenditure estimates are positively biased, but allowances can be made for the bias. Adjusted values were used to determine the CT 9500 HR performance equivalents of current run test standards that are provided as an appendix to this report.

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Appendix A

Computing Steady-State Energy Expenditure

Rationale

Energy expenditure estimates were computed from open-circuit spirometry during the last 6 min of each exercise bout. The energy requirement was constant throughout each bout because resistance and rpm were constant. The energy provided by aerobic processes would equal this constant requirement only during the latter part of each bout. During the earlier parts, aerobic processes provided only part of the required energy early in the bout because it takes time for aerobic energy processes to be activated. An exponential curve rising to a maximum is widely used as a functional description of the activation pattern. Estimates of the half-time for the rise in this function range from ~20 sec to ~30 sec.

The half-time value determines how rapidly the exponential function approaches its maximum. The difference between the current uptake and the maximum uptake decreases by 50% every half-time period. For example, if the half-time is 30 sec, oxygen uptake reaches roughly half of the maximum value for the function in the first 30 sec. By 1 min, the oxygen output is close to 75% of the requirement. The remaining difference is halved every subsequent 30 sec. Applying this model, aerobic processes supply 99.97% of the energy required at 6 min.

The exponential model is only approximate. The mathematical form of this model is such that the curve would never reach steady state in any real application. Instead, the function gets infinitely close to a maximum after an infinite period of time. In reality, aerobic energy expenditure reaches a steady state after a period of time. This steady state probably is reached prior to 6 min. The 30-sec estimate for the half-time of the rise is generous. Values of 25 sec or even 20 sec are defensible. Given these values, aerobic processes would provide 99.97% of the energy required to sustain the exercise after 5 min and 4 min, respectively.

The exponential description of the activation of aerobic energy processes is a useful approximation even if it is not literally true. The model shows that measures taken from 6 min on can be expected to be very close to steady-state uptake. If the exponential model were literally correct, the subsequent increase in uptake would be at most .03%. The subsequent increase will be less than .03% if half-time is less than 30 sec. Even the maximum value of .03% is likely to be much less than the variation introduced by technical aspects of oxygen uptake measurement such as variation in respiration rates. Measured uptakes after 6 min therefore should be reasonable practical indicators of the steady-state energy expenditure rate.

Analytic Verification

Preliminary analyses confirmed that steady-state oxygen uptake was reached. The GLM procedure of SPSS-PC fitted two models. The first model included resistance and rpm as predictors of breath-by-breath oxygen uptake. The second model added time within the exercise bout as a predictor. The breath-by-breath measures of oxygen uptake from the 6th minute to the end of exercise were the dependent variables. These two models were fitted for each individual separately.

A steady-state process is constant over time. The analyses therefore focused on the relationship of oxygen uptake with time. The statistical model to describe this relationship included resistance and rpm. This inclusion made it possible to combine the measures from different exercise bouts into a single model. The results therefore indicated whether a general trend in oxygen uptake was discernible. A strong association of time with oxygen uptake would be reason to reject the hypothesis that uptake reached steady state. A separate model was fitted for the set of exercise bouts performed by each study participant.

Steady state was reached. Time explained an average of 0.7% of the variation in oxygen uptake during the last 6 min of exercise. These very weak effects were statistically significant in some cases, but it must be remembered that the analyses included >400 data points for each subject. Any relationship that is not literally zero will be statistically significant if the sample is large enough.[8] Effect size is a better index of importance when sample sizes are very large. By this criterion, time would be important for theory or practical applications only if it explained at least 1% of the variance (Cohen, 1988). Time effects did not meet this minimum criterion.

[8] The correlation coefficient can be used to illustrate this point. One significance test for correlations uses Fisher's *r*-to-*z* transformation to produce a statistic that is approximately normally distributed with a standard deviation, $s = \sqrt{[1/(N - 3)]}$, where N is the sample size. When r is close to zero, Fisher's transformation has very little effect, so $z = r/s \approx r^*(N - 3)$. The null hypothesis is rejected if $z \geq c$ where c is a criterion value (e.g., $z = 1.96$ for $p < .05$, 2-tailed). Substituting $r^*(N - 3)$ for z, if $r \neq .00$, $r^*(N - 3) \geq c$ will be true if $N \geq c/r + 3$. In principal, the sample size, N, always can be increased until this condition is satisfied. Thus, any correlation, r, will be significant given a large enough sample. Most other measures of effect size can be converted to correlations (Hedges & Olkin, 1985), so the proof applies to those measures.

Appendix B

Details of Analyses Relating EE_{CT} to EE_{O2}

EE_{CT} was strongly related to EE_{O2} (Figure 2, p. 9). Analyses indicated that the relationship could be summarized by a simple linear model. The main body of this report provided a statistical model describing the association. This appendix provides supporting details for that final model.

EE_{O2} as a Function of EE_{CT}

EE_{CT} was greater than EE_{O2} for 72 of 73 bouts. For the remaining bout, EE_{CT} was 213.00 kcal compared to 224.91 kcal for EE_{O2}. This bout was an outlier by several criteria. The studentized-deleted $z = 3.93$ was well above the 3.00 recommended for identifying outliers. Cook's d was more than 3 times the next largest value ($d = .298$ vs. $d = .087$). DFFIT, a measure of the impact of the data point on the overall goodness of fit of the model, was nearly twice the next largest value (DFFIT = 0.85 vs. DFFIT = 0.43). The same participant completed 9 other bouts. The data for those 9 bouts were very close to the general regression line. The single bout, therefore, was exceptional for the individual participant as well as for the sample as a whole. These facts gave reason to classify the data point an outlier (Belsley, Kuh, & Welsch, 1980; Barnett & Lewis, 1978). This exercise bout was dropped from subsequent analyses.

Although Figure 2 shows a strong trend toward a linear relationship between EE_{O2} and EE_{CT}, the line relating the two measures did not pass through zero. This aspect of the figure reflected the fact that, on average, EE_{CT} was 32.95 kcal/min higher than EE_{O2}. This difference was highly significant statistically, $t(1, 72) = 25.38$, $p < .001$. The regression of EE_{O2} on EE_{CT} indicated that the two estimates corresponded well after allowing for this offset:

$$EE_{O2}' = 1.008 * EE_{CT} - 34.370 \quad \text{(Equation B-1)}$$

In this equation, EE_{O2}' is the predicted value for EE_{O2}. Equation B-1 accounted for 81% of the EE_{O2} variance. The SEE was 11.09 kcal. The 95% CI for the slope was (0.894, 1.122). The 95% CI for the intercept was (-55.00, -13.74). Thus, both the slope and intercept differed significantly ($p < .05$) from zero. However, the confidence interval for the slope included 1.000, indicating that the sample estimate did not differ from this ideal value.

Analysis of Residuals

Regression residuals (i.e., $EE_{O2} - EE_{O2}'$) were analyzed to identify systematic sources of error in the predictions. An ANCOVA model was evaluated with rpm, resistance, bike, and weight as predictors. The analysis showed that:

- All interactions between rpm, resistance, and bike were nonsignificant ($p > .216$).
- Residuals were not related to rpm, $F(3, 64) = 1.26$, $p > .294$. This predictor accounted for only 0.8% of the overall EE_{O2} variance.
- Residuals were not related to bike, $F(1, 67) = 2.35$, $p > .129$; bike accounted for less than 0.5% of the overall EE_{O2} variance.

- Resistance was significantly related to the size of residuals, F (2,68) = 7.54, $p < .001$. The average residual for resistance level 5 was 6.61 kcal. This value differed significantly from the averages of -3.42 kcal at level 10 ($p < .002$) and -2.60 kcal at level 15 ($p < .005$).
- Combining levels 10 and 15 reduced resistance to a dichotomy with a loss of only <0.1% in explanatory power of the model.
- A final analysis combined weight, F (1, 69) = 5.09, $p < .028$, and the resistance dichotomy, F (1, 69) = 15.20, $p < .001$, into a single model that accounted for 4.1% of the overall EE_{O2} variance.
- When expressed as a regression model with EE_{CT}, weight, and the resistance dichotomy as predictors the above findings produced:

$$EE_{O2} = (1.087*EE_{CT}) + (.273*\text{Weight}) - (11.292*\text{Level Dichotomy}) - 49.979 \qquad \text{(Equation B-2)}$$

Given $R^2 = .857$, this model accounted for 4.7% more of the variance than Equation 1. The increased explanatory power meant that SEE decreased from 11.09 kcal to 9.75 kcal. The EE_{CT} regression coefficient increased from 1.008 to 1.087, but the 95% CI (.973, 1.201) still included 1.00.

Individual Differences: Simple Analysis of Variance (ANOVA). Some individuals may consistently use less energy than others when running at a given speed. Exercise physiologists refer to this characteristic as the individual's running economy (Saunders, Pyne, Telford, & Hawley, 2004). The EE_{CT} algorithm does not allow for these differences, so EE_{CT} may consistently overestimate energy expenditure for some individuals while consistently underestimating for others. The residuals from Equation B-1 were analyzed to determine whether the equivalent of running economy was evident in the present data. The analysis treated each test participant as a "group" in a 1-way ANOVA with the residuals from Equation B-2 as the dependent variable. Findings were:

- Individual differences accounted for 32.7% of the variance, F (9, 61) = 3.34, $p < .003$.
- Averages ranged from -8.36 kcal to 11.92 kcal. Adding these values to average intercept of Equation B-1 (i.e., -34.37) would produce individual equations with intercepts ranging from -42.73 kcal to -22.45 kcal.[9]

Individual Differences: General Linear Model (GLM). A series of GLM models provided a second examination of possible differences in running economy. The predictors in this model were participant, which was treated as a grouping variable for exercise bouts, and EE_{CT}, which was treated as a covariate.

- *EE_{CT} Only*. In this model, which was identical to the basic regression model in Equation B-1, EE_{CT} was the only predictor. EE_{CT} was a highly significant predictor of EE_{O2}, F (1, 70) = 291.50, p < .001, and accounted for 80.6% of the EE_{O2} variance.
- *EE_{CT} With Individual Intercepts*. The second model added study participant as a group variable. Adding the group variable produced a model that consisted of parallel regression lines. The slope of EE_{O2} on EE_{CT} was the same for all individuals, but the

[9] The simple differences between EE_{CT} and EE_{O2} were examined as an alternative method of estimating the effect of individual on the correspondence between the two estimates. The average difference varied significantly from person to person, F (9, 62) = 6.81, $p < .001$. Nearly half (49.7%) of the variation in differences could be explained by individual. The average values ranged from -51.61 kcal to -19.64 kcal. The spread of differences was slightly larger than that based on the residuals analysis, but the choice of analytic approach would not affect the conclusions from the analysis.

intercepts differed. Differences in the intercepts accounted for 8.4% of the EE_{O2} variance, F (9, 61) = 5.19, $p < .001$.

- EE_{CT} *With Individual Intercepts and Slopes*. A third GLM model added individual differences in slope. This addition increased predictive accuracy by only 0.4%, a statistically nonsignificant increase, F (9, 51) = .213, $p = .991$.
- The final GLM model consisted of a common regression slope of $b_1 = 1.020$ (SE = .051) and individual intercepts. The slope was not significantly different from 1.000, $t_{1, 61} = 0.39$, $p > .697$, 2-tailed. Intercepts ranged from -58.34 kcal to -22.96 kcal.

Individual Differences: Hierarchical Linear Model (HLM). The preceding analyses of individual differences did not allow for the fact that exercise bouts were nested within subjects. When analyzed by traditional methods, such as regression or GLM, this data structure can yield misleading parameter estimates (cf., Raudenbush & Bryk, 2002). HLM methods provide a statistical basis for inferences that makes appropriate allowance for the data structure. In the present case, the application of these methods did not affect conclusions about the final model. The data required a model that combined significant variation in the regression intercepts, $\chi^2 = 104.92$, 9 *df*, $p < .001$, with a common regression slope, $\chi^2 = 2.17$, 9 *df*, $p > .988$. The estimated slope was identical to the GLM value, i.e., $b_1 = 1.020$.

Conclusion. The supplementary analyses converged on a model with two defining characteristics. First, the slope of the regression of EE_{O2} on EE_{CT} was ~1.000. Second, the model should include individual differences in the intercept of the equation.

Test Constraints

Equation B-2 provided a model relating EE_{CT} with EE_{O2} controlling for resistance and the test subject's weight. Because the resistance level in Equation B-2 is a dichotomy, requiring that all tests be conducted with resistance ≥10 would simplify this equation by eliminating the resistance effect. Repeating the original analysis with data from bouts performed with resistance at 10 or 15 produced the following

$$EE_{O2} = 1.075*EE_{CT} - 49.958 \qquad \text{(Equation B-3).}$$

Major points to consider regarding this question were:

- The EE_{CT} regression coefficient (1.075) for was larger than that in Equation B-1 (1.008) and smaller than that in Equation B-2 (1.087). However, the 95% CI of (.965, 1.185) contained both of those earlier estimates and 1.000 as plausible values.
- The accuracy of prediction increased. The proportion of EE_{O2} variance explained increased from 81.0% to 88.9%. SEE dropped from the 9.75 kcal for Equation B-1 to 8.91 kcal.
- Weight was eliminated as a predictor of EE_{O2}. When weight was added to Equation B-3, the regression coefficient was not significant, $b = .15$, $SE_b = .157$, t (1, 46) = .953, $p > .345$. SEE actually increased slightly from that in Equation B-3 (SEE = 8.92 vs. 8.91).[10]

[10]SEE increased because the t value for weight was <1.00. This result indicated that the degree of freedom used to estimate the regression coefficient for weight accounted for less than the average amount of error variance. The average error variance for the remaining degrees of freedom therefore had to increase.

Appendix C

Details of Analysis Relating EE_{CT} and Run Time

A three-step procedure to convert energy expenditure into estimated run time was described in the introduction to Study 3. That procedure will accurately predict the actual run times if EE_{CT} correctly quantifies energy expenditure rate. The results of Study 2 indicated that EE_{CT} actually overestimates energy expenditure. Given this bias, the estimated times produced by the three-step procedure will be faster than the observed times. Study 3 was undertaken to test the hypothesis that predicted times would be too fast. Study 3 also provided the opportunity to explore different methods of correcting for energy expenditure bias if necessary. This appendix describes the exploration process that led to Equation 5 on p. 11 as the optimal method of converting EE_{CT} to run time estimates.

Analytic Run Time Predictions

Analytic predictions of run time applied the three-step procedure using the EE_{CT} values reported by the CT 9500 HR with no adjustment. The average estimated run time was 10:52 min (*SD* = 2:57). The actual run times averaged 12:25 (*SD* = 2:27). The difference of 1:33 min was highly significant, t (1,39) = -8.09, $p < .001$. Thus, run times based on raw EE_{CT} values were too fast as expected from the results of Study 2.

Energy Expenditure Adjustments

The analytic run time estimates were consistent with the Study 2 evidence that EE_{CT} was higher than the actual energy expenditure. Subtracting an appropriate constant from EE_{CT} would be the simplest method of correcting this bias. Study 2 indicated that the bias was 34.37 kcal (Equation 2, p. 6). A second set of run time predictions therefore was generated with (EE_{CT} – 34.37) in place of EE_{CT}. The average run time obtained with this adjusted EE_{CT} was 13:16 min. These estimates were, on average, 0:51 min slower than the observed run times. The difference was highly significant, t (1,39) = 3.98, $p < .001$. The overcorrection was even worse when the bias estimate of 49.98 kcal from Equation B-3 (p. 21) was substituted for the Equation 2 energy adjustment. The estimated average time became 14:46 min for a highly significant, t (1, 39) = 8.94, $p < .001$, difference of 2:21 min.

Time Adjustment: An Empirical Model

The plot of run time as a function of the analytic estimate of run time (Figure 3, p. 11) suggested an alternative approach to predicting run times. The relationship between the analytic estimates of run times and actual run times appeared to be linear for both men and women. The regression lines for men and women were almost parallel, so the slopes of the regression lines were approximately equal. ANCOVA carried out with the SPSS-PC GLM procedure provided a quantitative model to represent these visual impressions. The results were:

- The linear relationship between the analytic run time estimates, T, and actual run times accounted for 75.1% of the run time variance, F (1, 37) = 117.67, $p < .001$.
- The difference in the slopes of the regression lines for men and women accounted for less than 0.2% of the run time variance. This effect was trivial by Cohen’s (1988) standards and was not statistically significant, F (1, 37) = .64, $p > .426$.
- The difference in the intercepts for men and women accounted for 10.7% of the run time variance. The difference was highly significant statistically, F (1, 33) = 28.62, $p < .001$.

These results indicated that run time could be accurately predicted by computing the analytic run time and then adding a constant to the result. The constant depended on the gender of the test subject. This method of model construction was labeled “time adjustment” to contrast it with the “energy adjustment” methods based on Study 2 findings.

Alternative Models of EE_{CT} and Run Time

The ANCOVA results provided a method of converting EE_{CT} to run time. The method computed the analytic time estimate, T, and subtracted a constant from that estimate. The constant that was subtracted depended on the sex of the person involved. The resulting time adjustment model was more accurate than either of the energy adjustment models considered previously.

The apparent advantage of time adjustment over energy adjustment might be illusory. The ANCOVA analysis produced time adjustments that optimized the prediction of run time in the present data. The ANCOVA also introduced separate adjustments for men and women. The energy adjustment models differed in two important respects. First, the adjustments relied on parameter values obtained in Study 2 rather than choosing values that maximized predictive accuracy in the present data. Second, the adjustment was the same for both men and women. Both of these constraints would be expected to reduce model accuracy relative to an alternative that had more parameters with the values of those parameters chosen to maximize prediction in the present data.

Further models were developed to provide a fair comparison of time and energy adjustment methods of correcting EE_{CT} bias. These models were of the following general form

$$t' = b + (2413*\text{weight}) / ([EE_r\text{-}a]) \qquad \text{(Equation C-1)}$$

The *a* and *b* parameters in Equation C-1 represent two possible methods of adjusting run time predictions. Assigning a nonzero value to parameter *a* adjusts the energy expenditure rate. Assigning a nonzero value to parameter *b* adjusts the time. Different models can be constructed by varying which parameters are set equal to zero. The following labels summarize the models that were considered.

- Analytic Model (Model A): Parameter $a = 0$; parameter $b = 0$. This model is the analytic conversion of EE_{CT} to run time without adjustments. This model is the three-step approach outlined in the introduction of Study 3.
- Energy Adjustment Model (Model E): Parameter $a = 0$; parameter $b \neq 0$. This model is an energy adjustment model because a constant is subtracted from EE_{CT}. This model differs from the initial energy adjustment models because the constant has been chosen to optimize prediction in the present data.
- Time Adjustment Model (Model T): Parameter $a \neq 0$; parameter $b = 0$. This model is a time adjustment model because a constant is subtracted from the analytic estimate of run time. In this case, the model applied a single adjustment to men and women.
- Combined Energy and Time Adjustments Model (Model ET): Parameter $a \neq 0$; parameter $b \neq 0$. This model combined rate and time adjustments to determine the maximum predictive accuracy when adjustments were the same for men and women.

Table C-1 summarized the results of these analyses. The most important findings were:

Table C-1. Models of EE_r and Run Time

Model	Estimated Parameter	Estimate	95% Confidence Interval Lower Bound	Upper Bound	Model R^2	SEE
A	None				.404	1:55
E	EE_r	1.87	1.46	2.28	.750	1:14
T	Time	1:33	1:10	1:56	.751	1:14
ET	Time	0:48	-0:18	1:52		
	EE_r	1.04	-0.26	2.34	.763	1:13

Note. EE_r = *a* in Equation C-1 (in kcal·min^{-1}). Time = *b* in Equation C-1 (in min:sec).

- The analytic approach (Model A) was not competitive. The predictive power of every other model in Table 2 was substantially greater than that of the analytic model.
- The energy and time adjustment approaches (Models E and T) were interchangeable. The trivial difference in explanatory power observed at the third decimal place in the R^2 values was too small to yield an effective difference in predictive accuracy. This point is clearly evident in the fact that SEE was the same for both models.
- Combining energy and time adjustments (Model ET) produced only a slight improvement on adjusting either factor alone. The ET model accounted for 1.2% more of the run time variance, so SEE was 1.2 sec smaller. However, because the parameter estimates were strongly related (r = -.936), the confidence intervals for both parameters included zero. The net result was an accurate model with no significant predictors.

Bias Analyses

Models E and T were interchangeable when adjustments were chosen to optimize prediction in the present data. However, the models might differ if the scope of the comparison were extended beyond simple prediction of run times. One model might be biased while the other was not. The working definition of bias was that errors in the prediction of run times would be consistently positive or consistently negative depending on the characteristics of the test subject. The characteristics of interest included age, gender, and preferences regarding the resistance and rpm in the elliptical trainer bout.

Residual differences between observed and predicted run times (i.e., t – t') were the basis for the operational definition of bias. Bias would be evident if the elliptical trainer bout produced time estimates that were consistently too high or too low. Residuals were created for time adjustment and rate adjustment models to determine whether errors in prediction for either model were related to age, gender, resistance, or rpm. Significant associations would indicate bias in the simple model. The model could be extended to remove this bias by incorporating the factor that was related to the residuals.

The residuals analyses included both energy and time adjustment models because the earlier comparisons gave no basis for choosing one over the other. Differential bias might provide a basis for making the necessary choice. In fact, the residuals were correlated with several predictors (Table C-2).

Table C-2. Residuals Analysis for Time Prediction Models

	Bivariate Correlation Residual Adjusted for:		Partial Correlation[a] Residual Adjusted for:	
	Energy	Time	Energy	Time
Gender	.382*	.634**	.---	.---
Age	-.231	-.117	-.228	-.108
Weight	-.340*	-.413**	-.189	-.150
Bike	.122	.151	.123	.177
Resistance	-.018	-.413**	.345*	.017
rpm	.297	-.045	.498**	.246

[a]Controlling for gender.

*$p < .05$ **$p < .01$

The bivariate correlations were stronger for time adjustment than for energy adjustment. However, gender was the strongest correlate of the residuals regardless of model. This element of the findings suggested that any final model would include gender as a predictor. If so, the next question was whether the final model would include additional predictors.

The potential for adding other predictors was explored by computing partial correlations controlling for gender. The partial correlations in Table C-2 indicated that gender would suffice when coupled with time adjustment, but an energy adjustment model would have to include at least rpm as an additional factor to consider in predicting run time.

Regression models were constructed to compare the effects of extending the basic time and rate adjustment models to incorporate corrections for bias. The SEE for the rate adjustment model was 1:00.4 min when both gender and rpm were added to the energy adjustment model. The SEE for the time adjustment model was 0:57.6 min, with gender as the only added adjustment factor.

Complete Time Adjustment Model

The residuals analyses indicated that time adjustment was preferable to energy adjustment. This approach provided better accuracy in predicting run times with fewer adjustments. When expressed as a prediction formula, the full-time adjustment model was

$$t' = (0.900*T) + (1.660*Gender) + 0.249 \qquad \text{(Equation C-2)}$$

Key facts to consider with regard to the model in Equation C-2 were:

- Comparing the squared multiple correlations for Equation C-2 and Model E in Table C-1, gender accounted for 10.7% of the run time variance ($R^2 = .858$ vs. $R^2 = .751$). The increased explanatory power produced a decrease in SEE from 1:14 min to 0:57 min.
- Adding other variables to Equation C-2 would not improve the predictions.
  - The partial correlations were age, partial $r = -.038$; weight, partial $r = -.022$; percent body fat, partial $r = .078$; and resistance, partial $r = -.181$.
  - None of these partial associations was significant ($p > .270$).
  - None of these predictors accounted for more than 0.5% total run time variance.

- The constant in Equation C-2 was not significantly different from zero, $t\ (1, 38) = .31$, $p > .761$. The model therefore could be simplified by deleting this parameter to obtain:

  $$t' = (0.837*T) + (1.092*Gender) \qquad \text{(Equation C-3)}$$

  Trimming the nonsignificant constant from Equation C-2 restored 1 *df* while increasing error variance only slightly. As a result, the Equation C-3 SEE actually was slightly less than the Equation C-2 SEE (0:57.0 min to 0:56.4 min).[11]

Gender Effect on Slope

Equations C-2 and C-3 applied a single regression slope to men and women when relating observed run time to analytic run time. ANCOVA methods were applied to test the utility of having different slopes for men and women. The ANCOVA included gender as a categorical variable and T as a continuous covariate. The model consisted of the main effects for gender and T and the interaction between those predictors. A significant interaction would indicate that the regression slopes differed for men and women. The interaction accounted for 0.2% of the run time variance and was not significant, $F\ (1, 37) = 0.64$, $p > .426$.

A Constrained Model

The regression slopes for T in Equations C-2 and C-3 were 10–15% less than 1.000. This empirical difference may not be an accurate indication of the utility of replacing simple unit weighting with an empirically derived value. A constrained model was fitted to the data to directly assess the utility of the empirically derived estimate. The model, $t' = T + (b*Gender)$, was fitted using the nonlinear regression routine of SPSS-PC. The result was

$$t' = T' + (1.126*Gender) \qquad \text{(Equation C-4)}$$

Predictions from Equation C-4 were slightly less accurate than those from Equation C-3 ($R^2 = .843$ vs. $R^2 = .858$). The models differed by only 1 *df*, so the difference in explanatory power (1.5%) would satisfy Cohen's (1988) minimum criterion for concluding that a parameter was a useful addition to a model. However, Cohen (1988) was concerned primarily with identifying effects that would have theoretical and/or practical importance. In this case, the practical importance of the additional parameter was questionable. Replacing unit weighting with the sample-optimized weight reduced the typical error from SEE = 0:58.4 min (Equation C-4) to SEE = 0:57.0 min (Equation C-3). Unit weighting therefore increased the 95% CI for individual time predicted times (i.e., t' for a given participant) by only 2.83 sec.

Energy Cost of Running: A Digression

The various models examined in this appendix all share a common untested assumption. Every analysis assumed that the energy cost of running is 1 $cal \cdot kg^{-1} \cdot km^{-1}$. This figure is an accepted value in exercise physiology (McArdle et al., 2001), but it might not apply to the specific modeling problem at hand. The validity of this assumption for the current application was tested by using nonlinear regression to fit the equation

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[11] SEE can decrease even though the explanatory power of the model increases. This situation arises whenever the F associated with a predictor is less than 1.00. In this case, 1 *df* is restored to the model and the increase in the error is less than the average for the prior model. As a result, the average error decreases.

$$t' = a + ([b*weight]/EE_r) \qquad \text{(Equation C-5)}$$

In this analysis, the energy cost of running 1.5 miles was a parameter to be estimated (i.e., *b*) rather than the fixed value suggested by prior research.

The empirical estimate of the energy cost of running was very close to the accepted value. The nonlinear regression produced the equation

$$t' = 1.49 + (2.426/EE_r) \qquad \text{(Equation C-6)}$$

The estimated energy cost of 2.426 $kcal \cdot kg^{-1}$ for the 2.413 km (i.e., 1.5-mile) distance was only 0.6% higher than the accepted value. Given that the standard error for this estimate was 0.224 $kcal \cdot kg^{-1} \cdot km^{-1}$, the difference of .013 $kcal \cdot kg^{-1}$ between the empirical and theoretical values did not approach statistical significance, $t\,(1, 39) = .06$, $p > .952$, 2-tailed. The correspondence between the two values clearly was close enough to make it unlikely that the use of 1 $kcal \cdot kg^{-1} \cdot km^{-1}$ as the energy cost of running 1 km significantly affected the study findings.

Conclusions

Run times based on EE_{CT} have a positive bias. The bias can be eliminated by adjusting EE_{CT} before computing the run time estimate or by adjusting the time prediction obtained with the reported EE_{CT}. These methods were equally accurate when the adjustments were estimated from the data in this study. However, both methods produced biased run time predictions. The bias was linked to gender regardless for both energy and time adjustments. The choice of rpm was an additional determinant of bias in the energy adjustment model. The time adjustment model with a correction for gender bias produced predictions that were more accurate than the energy adjustment model with corrections for gender and rpm. The time adjustment model therefore was preferable to the energy adjustment approach on the grounds of greater accuracy and greater simplicity (i.e., parsimony).

Time adjustment is a simple modification of the basic three-step procedure described in the introduction to Study 3. The three-step estimates are adjusted by adding 1:08 min for men and 2:15 min for women. The SEE of 0:58 min for this model is trivially greater than the SEE for laboratory measures of VO_{2max} as predictors of run 1.5-mile times (i.e., 0:57 min).

The estimated time adjustments are based on a small sample of men and women. Despite this, the adjustments were estimated with reasonable accuracy. The 95% CI for the adjustments was ±0:13 min in this study.[12] This potential error should not be dismissed casually, but it is much smaller than the average error of 1:33 min that would be expected if EE_{CT} were simply converted to run time estimates.

The absence of age adjustments might raise doubts about the model. However, adding of age adjustments would not improve on Equation C-4 given the weak association of age with the residuals from Equation C-4 ($r = -.117$, $p > .906$, 2-tailed). Perhaps age is not important because age has similar effects on run test performance and CT 9500 HR performance. If those effects

[12] The 95% CI for the adjustments was ±0:12.5 min. Applying Wherry's (1984, p. 93) shrinkage formula to estimate the expected error in a new sample would increase the interval to ±0:12.8 min. The increase was modest because the substantial R^2 for the equation was achieved with just a few parameters. Both interval estimates round to the value of ±0:13 min reported in the text.

occur in parallel, the changes would not affect the relationship between the performance measures. If so, age effects would not be expected in the present analyses.

Appendix D. Tables to Convert CT 9500 HR Performance to Run Time Equivalent for Men

The following table applies Equation 6 to convert the calorie expenditure reported by the CT 9500 HR to an equivalent run time for women. The table gives run times by subject weight. Two dimensions are necessary because the energy expenditure required for running a given distance increases with weight.

Interpolation is necessary when using the table to obtain times for some combinations of weight and energy expenditure. The tabled values apply to weights between 90 and 300 pounds in 5-pound increments. Levels of energy expenditure have been tabled 2.5 calorie increments. The levels are close enough together to permit accurate linear interpolation between tabled values for test subjects whose weight/energy expenditure rate combination is not listed in the table provided the combination is within the range of tabled values.

The tabled values were constrained to match the performance standards provided in the Physical Readiness Test. The tables provide conversions for the energy expenditures that convert to the minimum and maximum times in the PRT tables for men. The minimum time in those tables is the time that must be achieved to be classified as “Outstanding/High” in the 17-21 age group. That time currently is 8:15. Therefore, the highest energy expenditure that has been tabled for each weight is the first value that converted to a time less than 8:15 min. The maximum time in the PRT tables for men is the time that would be required for a man 65 years of age or older to avoid failing the test. That time currently is 20:35 min. A man 65 years of age or older who had this time would be classified as “Probationary.” If his time were even a second slower he would be a PRT failure. The lowest energy expenditure rate in the table for each weight therefore was the first 2.5-calorie increment that converted to a time in excess of 20:35 min.

					Weight (in pounds)						
Cal	90	95	100	105	110	115	120	125	130	135	140
60.0	20:49										
62.5	20:02										
65.0	19:19	20:19									
67.5	18:38	19:36	20:35								
70.0	18:01	18:57	19:53	20:49							
72.5	17:26	18:20	19:14	20:09							
75.0	16:53	17:46	18:38	19:31	20:23						
77.5	16:23	17:13	18:04	18:55	19:46	20:37					
80.0	15:54	16:43	17:32	18:22	19:11	20:00	20:49				
82.5	15:27	16:15	17:03	17:50	18:38	19:26	20:14				
85.0	15:02	15:48	16:35	17:21	18:07	18:54	19:40	20:26			
87.5	14:38	15:23	16:08	16:53	17:38	18:23	19:08	19:53	20:38		
90.0	14:15	14:59	15:43	16:27	17:11	17:54	18:38	19:22	20:06	20:49	
92.5	13:54	14:37	15:19	16:02	16:45	17:27	18:10	18:52	19:35	20:17	
95.0	13:34	14:15	14:57	15:38	16:20	17:01	17:43	18:24	19:06	19:47	20:29
97.5	13:15	13:55	14:36	15:16	15:56	16:37	17:17	17:58	18:38	19:19	19:59
100.0	12:57	13:36	14:15	14:55	15:34	16:14	16:53	17:32	18:12	18:51	19:31
102.5	12:39	13:18	13:56	14:35	15:13	15:52	16:30	17:08	17:47	18:25	19:04
105.0	12:23	13:00	13:38	14:15	14:53	15:31	16:08	16:46	17:23	18:01	18:38
107.5	12:07	12:44	13:21	13:57	14:34	15:10	15:47	16:24	17:00	17:37	18:14
110.0	11:52	12:28	13:04	13:40	14:15	14:51	15:27	16:03	16:39	17:15	17:50
112.5	11:38	12:13	12:48	13:23	13:58	14:33	15:08	15:43	16:18	16:53	17:28
115.0	11:24	11:58	12:33	13:07	13:41	14:15	14:50	15:24	15:58	16:33	17:07
117.5	11:11	11:45	12:18	12:52	13:25	13:59	14:32	15:06	15:39	16:13	16:46
120.0	10:58	11:31	12:04	12:37	13:10	13:43	14:15	14:48	15:21	15:54	16:27
122.5	10:46	11:19	11:51	12:23	12:55	13:27	13:59	14:32	15:04	15:36	16:08
125.0	10:35	11:06	11:38	12:09	12:41	13:12	13:44	14:15	14:47	15:19	15:50
127.5	10:24	10:55	11:26	11:56	12:27	12:58	13:29	14:00	14:31	15:02	15:33
130.0	10:13	10:43	11:14	11:44	12:14	12:45	13:15	13:45	14:15	14:46	15:16
132.5	10:03	10:32	11:02	11:32	12:02	12:31	13:01	13:31	14:01	14:30	15:00
135.0	9:53	10:22	10:51	11:20	11:50	12:19	12:48	13:17	13:46	14:15	14:45
137.5	9:43	10:12	10:41	11:09	11:38	12:07	12:35	13:04	13:33	14:01	14:30
140.0	9:34	10:02	10:30	10:58	11:27	11:55	12:23	12:51	13:19	13:47	14:15
142.5	9:25	9:53	10:20	10:48	11:16	11:43	12:11	12:39	13:06	13:34	14:02
145.0	9:17	9:44	10:11	10:38	11:05	11:32	11:60	12:27	12:54	13:21	13:48
147.5	9:08	9:35	10:02	10:28	10:55	11:22	11:49	12:15	12:42	13:09	13:35
150.0	9:00	9:27	9:53	10:19	10:45	11:12	11:38	12:04	12:30	12:57	13:23
152.5	8:53	9:18	9:44	10:10	10:36	11:02	11:28	11:53	12:19	12:45	13:11
155.0	8:45	9:10	9:36	10:01	10:27	10:52	11:18	11:43	12:08	12:34	12:59
157.5	8:38	9:03	9:28	9:53	10:18	10:43	11:08	11:33	11:58	12:23	12:48
160.0	8:31	8:55	9:20	9:45	10:09	10:34	10:58	11:23	11:48	12:12	12:37
162.5	8:24	8:48	9:12	9:37	10:01	10:25	10:49	11:14	11:38	12:02	12:26
165.0	8:17	8:41	9:05	9:29	9:53	10:17	10:41	11:04	11:28	11:52	12:16
167.5	8:11	8:34	8:58	9:21	9:45	10:09	10:32	10:56	11:19	11:43	12:06
170.0	8:05	8:28	8:51	9:14	9:37	10:01	10:24	10:47	11:10	11:33	11:56
172.5		8:21	8:44	9:07	9:30	9:53	10:16	10:39	11:01	11:24	11:47
					Weight (in pounds)						
Cal	90	95	100	105	110	115	120	125	130	135	140

175.0	8:15	8:38	9:00	9:23	9:45	10:08	10:30	10:53	11:15	11:38
177.5	8:09	8:31	8:54	9:16	9:38	10:00	10:22	10:45	11:07	11:29
180.0	8:03	8:25	8:47	9:09	9:31	9:53	10:15	10:37	10:58	11:20
182.5		8:19	8:41	9:02	9:24	9:46	10:07	10:29	10:50	11:12
185.0		8:13	8:35	8:56	9:17	9:39	9:60	10:21	10:43	11:04
187.5		8:08	8:29	8:50	9:11	9:32	9:53	10:14	10:35	10:56
190.0		8:02	8:23	8:44	9:04	9:25	9:46	10:07	10:27	10:48
192.5			8:17	8:38	8:58	9:19	9:39	9:60	10:20	10:41
195.0			8:12	8:32	8:52	9:12	9:33	9:53	10:13	10:33
197.5			8:06	8:26	8:46	9:06	9:26	9:46	10:06	10:26
200.0			8:01	8:21	8:41	9:00	9:20	9:40	9:59	10:19
202.5				8:16	8:35	8:54	9:14	9:33	9:53	10:12
205.0				8:10	8:30	8:49	9:08	9:27	9:46	10:06
207.5				8:05	8:24	8:43	9:02	9:21	9:40	9:59
210.0				8:00	8:19	8:38	8:57	9:15	9:34	9:53
212.5					8:14	8:33	8:51	9:10	9:28	9:47
215.0					8:09	8:27	8:46	9:04	9:22	9:41
217.5					8:04	8:22	8:40	8:58	9:17	9:35
220.0						8:17	8:35	8:53	9:11	9:29
222.5						8:13	8:30	8:48	9:06	9:23
225.0						8:08	8:25	8:43	9:00	9:18
227.5						8:03	8:20	8:38	8:55	9:12
230.0							8:16	8:33	8:50	9:07
232.5							8:11	8:28	8:45	9:02
235.0							8:07	8:23	8:40	8:57
237.5							8:02	8:19	8:35	8:52
240.0								8:14	8:31	8:47
242.5								8:10	8:26	8:42
245.0								8:06	8:22	8:38
247.5								8:01	8:17	8:33
250.0									8:13	8:29
252.5									8:09	8:24
255.0									8:05	8:20
257.5									8:01	8:16
260.0										8:12
262.5										8:08
265.0										8:04

	Weight (in pounds)										
Cal	145	150	155	160	165	170	175	180	185	190	195
97.5	20:39										
100.0	20:10	20:49									
102.5	19:42	20:21									
105.0	19:16	19:53	20:31								
107.5	18:50	19:27	20:04	20:40							
110.0	18:26	19:02	19:38	20:14	20:49						
112.5	18:03	18:38	19:13	19:48	20:23						
115.0	17:41	18:15	18:50	19:24	19:58	20:32					
117.5	17:20	17:53	18:27	19:00	19:34	20:08	20:41				
120.0	16:60	17:32	18:05	18:38	19:11	19:44	20:17	20:49			
122.5	16:40	17:12	17:45	18:17	18:49	19:21	19:53	20:25			
125.0	16:22	16:53	17:25	17:56	18:28	18:59	19:31	20:02	20:34		
127.5	16:04	16:35	17:05	17:36	18:07	18:38	19:09	19:40	20:11	20:42	
130.0	15:46	16:17	16:47	17:17	17:48	18:18	18:48	19:19	19:49	20:19	20:49
132.5	15:30	15:60	16:29	16:59	17:29	17:58	18:28	18:58	19:28	19:57	20:27
135.0	15:14	15:43	16:12	16:41	17:11	17:40	18:09	18:38	19:07	19:36	20:06
137.5	14:58	15:27	15:56	16:24	16:53	17:22	17:50	18:19	18:48	19:16	19:45
140.0	14:44	15:12	15:40	16:08	16:36	17:04	17:32	18:01	18:29	18:57	19:25
142.5	14:29	14:57	15:25	15:52	16:20	16:48	17:15	17:43	18:10	18:38	19:06
145.0	14:15	14:43	15:10	15:37	16:04	16:31	16:58	17:26	17:53	18:20	18:47
147.5	14:02	14:29	14:56	15:22	15:49	16:16	16:42	17:09	17:36	18:03	18:29
150.0	13:49	14:15	14:42	15:08	15:34	16:01	16:27	16:53	17:19	17:46	18:12
152.5	13:37	14:03	14:28	14:54	15:20	15:46	16:12	16:38	17:03	17:29	17:55
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157.5	13:13	13:38	14:03	14:28	14:53	15:18	15:43	16:08	16:33	16:58	17:23
160.0	13:02	13:26	13:51	14:15	14:40	15:05	15:29	15:54	16:19	16:43	17:08
162.5	12:51	13:15	13:39	14:03	14:28	14:52	15:16	15:40	16:05	16:29	16:53
165.0	12:40	13:04	13:28	13:52	14:15	14:39	15:03	15:27	15:51	16:15	16:39
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170.0	12:20	12:43	13:06	13:29	13:52	14:15	14:39	15:02	15:25	15:48	16:11
172.5	12:10	12:33	12:56	13:18	13:41	14:04	14:27	14:50	15:13	15:35	15:58
175.0	12:00	12:23	12:45	13:08	13:30	13:53	14:15	14:38	15:01	15:23	15:46
177.5	11:51	12:13	12:36	12:58	13:20	13:42	14:04	14:27	14:49	15:11	15:33
180.0	11:42	12:04	12:26	12:48	13:10	13:32	13:54	14:15	14:37	14:59	15:21
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187.5	11:17	11:38	11:59	12:20	12:41	13:02	13:23	13:44	14:05	14:26	14:47
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202.5	10:32	10:51	11:11	11:30	11:50	12:09	12:28	12:48	13:07	13:27	13:46
205.0	10:25	10:44	11:03	11:23	11:42	12:01	12:20	12:39	12:59	13:18	13:37
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210.0	10:12	10:30	10:49	11:08	11:27	11:45	12:04	12:23	12:42	13:00	13:19
212.5	10:05	10:24	10:42	11:01	11:19	11:38	11:56	12:15	12:34	12:52	13:11
215.0	9:59	10:17	10:36	10:54	11:12	11:31	11:49	12:07	12:26	12:44	13:02

	Weight	(in	pounds)								
Cal	145	150	155	160	165	170	175	180	185	190	195
217.5	9:53	10:11	10:29	10:47	11:05	11:23	11:42	11:60	12:18	12:36	12:54
220.0	9:47	10:05	10:23	10:41	10:58	11:16	11:34	11:52	12:10	12:28	12:46
222.5	9:41	9:59	10:16	10:34	10:52	11:10	11:27	11:45	12:03	12:20	12:38
225.0	9:35	9:53	10:10	10:28	10:45	11:03	11:20	11:38	11:55	12:13	12:30
227.5	9:30	9:47	10:04	10:22	10:39	10:56	11:14	11:31	11:48	12:06	12:23
230.0	9:24	9:41	9:59	10:16	10:33	10:50	11:07	11:24	11:41	11:58	12:16
232.5	9:19	9:36	9:53	10:10	10:27	10:44	11:01	11:18	11:35	11:51	12:08
235.0	9:14	9:30	9:47	10:04	10:21	10:38	10:54	11:11	11:28	11:45	12:01
237.5	9:09	9:25	9:42	9:58	10:15	10:32	10:48	11:05	11:21	11:38	11:54
240.0	9:04	9:20	9:36	9:53	10:09	10:26	10:42	10:58	11:15	11:31	11:48
242.5	8:59	9:15	9:31	9:47	10:04	10:20	10:36	10:52	11:09	11:25	11:41
245.0	8:54	9:10	9:26	9:42	9:58	10:14	10:30	10:46	11:03	11:19	11:35
247.5	8:49	9:05	9:21	9:37	9:53	10:09	10:25	10:41	10:57	11:12	11:28
250.0	8:45	9:00	9:16	9:32	9:48	10:03	10:19	10:35	10:51	11:06	11:22
252.5	8:40	8:56	9:11	9:27	9:42	9:58	10:14	10:29	10:45	11:00	11:16
255.0	8:36	8:51	9:06	9:22	9:37	9:53	10:08	10:24	10:39	10:55	11:10
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260.0	8:27	8:42	8:57	9:12	9:28	9:43	9:58	10:13	10:28	10:43	10:58
262.5	8:23	8:38	8:53	9:08	9:23	9:38	9:53	10:08	10:23	10:38	10:53
265.0	8:19	8:34	8:48	9:03	9:18	9:33	9:48	10:03	10:18	10:32	10:47
267.5	8:15	8:29	8:44	8:59	9:14	9:28	9:43	9:58	10:12	10:27	10:42
270.0	8:11	8:25	8:40	8:54	9:09	9:24	9:38	9:53	10:07	10:22	10:37
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275.0	8:03	8:17	8:32	8:46	9:00	9:15	9:29	9:43	9:58	10:12	10:26
277.5		8:13	8:28	8:42	8:56	9:10	9:24	9:39	9:53	10:07	10:21
280.0		8:10	8:24	8:38	8:52	9:06	9:20	9:34	9:48	10:02	10:16
282.5		8:06	8:20	8:34	8:48	9:02	9:16	9:30	9:44	9:57	10:11
285.0		8:02	8:16	8:30	8:44	8:58	9:11	9:25	9:39	9:53	10:07
287.5			8:12	8:26	8:40	8:53	9:07	9:21	9:35	9:48	10:02
290.0			8:09	8:22	8:36	8:49	9:03	9:17	9:30	9:44	9:57
292.5			8:05	8:19	8:32	8:45	8:59	9:12	9:26	9:39	9:53
295.0			8:02	8:15	8:28	8:42	8:55	9:08	9:22	9:35	9:48
297.5				8:11	8:25	8:38	8:51	9:04	9:18	9:31	9:44
300.0				8:08	8:21	8:34	8:47	9:00	9:13	9:27	9:40
302.5				8:04	8:17	8:30	8:43	8:56	9:09	9:22	9:35
305.0				8:01	8:14	8:27	8:40	8:53	9:05	9:18	9:31
307.5					8:10	8:23	8:36	8:49	9:02	9:14	9:27
310.0					8:07	8:20	8:32	8:45	8:58	9:10	9:23
312.5					8:04	8:16	8:29	8:41	8:54	9:07	9:19
315.0					8:00	8:13	8:25	8:38	8:50	9:03	9:15
317.5						8:09	8:22	8:34	8:47	8:59	9:11
320.0						8:06	8:18	8:31	8:43	8:55	9:08
322.5						8:03	8:15	8:27	8:40	8:52	9:04
325.0							8:12	8:24	8:36	8:48	9:00
327.5							8:09	8:21	8:33	8:45	8:57
330.0							8:05	8:17	8:29	8:41	8:53
332.5							8:02	8:14	8:26	8:38	8:50
335.0								8:11	8:23	8:34	8:46
337.5								8:08	8:19	8:31	8:43

					Weight (in pounds)						
Cal	145	150	155	160	165	170	175	180	185	190	195
340.0								8:05	8:16	8:28	8:39
342.5								8:02	8:13	8:25	8:36
345.0									8:10	8:21	8:33
347.5									8:07	8:18	8:30
350.0									8:04	8:15	8:27
352.5									8:01	8:12	8:23
355.0										8:09	8:20
357.5										8:06	8:17
360.0										8:03	8:14
362.5										8:01	8:11
365.0											8:09
367.5											8:06
370.0											8:03
372.5											8:00
375.0											

	Weight	(in	pounds)								
Cal	200	205	210	215	220	225	230	235	240	245	250
135.0	20:35										
137.5	20:14	20:42									
140.0	19:53	20:21	20:49								
142.5	19:33	20:01	20:29								
145.0	19:14	19:42	20:09	20:36							
147.5	18:56	19:23	19:49	20:16	20:43						
150.0	18:38	19:04	19:31	19:57	20:23	20:49					
152.5	18:21	18:47	19:13	19:38	20:04	20:30					
155.0	18:04	18:30	18:55	19:20	19:46	20:11	20:37				
157.5	17:48	18:13	18:38	19:03	19:28	19:53	20:18	20:43			
160.0	17:32	17:57	18:22	18:46	19:11	19:36	20:00	20:25	20:49		
162.5	17:17	17:42	18:06	18:30	18:54	19:19	19:43	20:07	20:31		
165.0	17:03	17:26	17:50	18:14	18:38	19:02	19:26	19:50	20:14	20:37	
167.5	16:48	17:12	17:35	17:59	18:22	18:46	19:09	19:33	19:57	20:20	20:44
170.0	16:35	16:58	17:21	17:44	18:07	18:30	18:54	19:17	19:40	20:03	20:26
172.5	16:21	16:44	17:07	17:30	17:52	18:15	18:38	19:01	19:24	19:47	20:09
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177.5	15:55	16:18	16:40	17:02	17:24	17:46	18:09	18:31	18:53	19:15	19:37
180.0	15:43	16:05	16:27	16:49	17:11	17:32	17:54	18:16	18:38	19:00	19:22
182.5	15:31	15:53	16:14	16:36	16:57	17:19	17:41	18:02	18:24	18:45	19:07
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197.5	14:25	14:45	15:05	15:25	15:45	16:05	16:25	16:45	17:05	17:25	17:45
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252.5	11:32	11:47	12:03	12:18	12:34	12:50	13:05	13:21	13:36	13:52	14:08

	Weight	(in	pounds)								
Cal	200	205	210	215	220	225	230	235	240	245	250
255.0	11:26	11:41	11:56	12:12	12:27	12:43	12:58	13:14	13:29	13:45	14:00
257.5	11:20	11:35	11:50	12:05	12:21	12:36	12:51	13:07	13:22	13:37	13:53
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345.0	8:44	8:56	9:07	9:19	9:30	9:41	9:53	10:04	10:16	10:27	10:39
347.5	8:41	8:52	9:04	9:15	9:26	9:38	9:49	10:00	10:12	10:23	10:34
350.0	8:38	8:49	9:00	9:12	9:23	9:34	9:45	9:57	10:08	10:19	10:30
352.5	8:35	8:46	8:57	9:08	9:19	9:30	9:42	9:53	10:04	10:15	10:26
355.0	8:31	8:43	8:54	9:05	9:16	9:27	9:38	9:49	10:00	10:11	10:22
357.5	8:28	8:39	8:50	9:01	9:12	9:23	9:34	9:45	9:57	10:08	10:19
360.0	8:25	8:36	8:47	8:58	9:09	9:20	9:31	9:42	9:53	10:04	10:15
362.5	8:22	8:33	8:44	8:55	9:06	9:17	9:27	9:38	9:49	10:00	10:11
365.0	8:19	8:30	8:41	8:52	9:02	9:13	9:24	9:35	9:46	9:56	10:07
367.5	8:16	8:27	8:38	8:49	8:59	9:10	9:21	9:31	9:42	9:53	10:04
370.0	8:13	8:24	8:35	8:45	8:56	9:07	9:17	9:28	9:39	9:49	9:60
372.5	8:11	8:21	8:32	8:42	8:53	9:03	9:14	9:25	9:35	9:46	9:56
375.0	8:08	8:18	8:29	8:39	8:50	9:00	9:11	9:21	9:32	9:42	9:53

Weight (in pounds)

Cal	200	205	210	215	220	225	230	235	240	245	250
377.5	8:05	8:15	8:26	8:36	8:47	8:57	9:08	9:18	9:28	9:39	9:49
380.0	8:02	8:13	8:23	8:33	8:44	8:54	9:04	9:15	9:25	9:36	9:46
382.5		8:10	8:20	8:30	8:41	8:51	9:01	9:12	9:22	9:32	9:43
385.0		8:07	8:17	8:28	8:38	8:48	8:58	9:08	9:19	9:29	9:39
387.5		8:04	8:15	8:25	8:35	8:45	8:55	9:05	9:16	9:26	9:36
390.0		8:02	8:12	8:22	8:32	8:42	8:52	9:02	9:12	9:23	9:33
392.5			8:09	8:19	8:29	8:39	8:49	8:59	9:09	9:19	9:29
395.0			8:06	8:16	8:26	8:36	8:46	8:56	9:06	9:16	9:26
397.5			8:04	8:14	8:24	8:34	8:43	8:53	9:03	9:13	9:23
400.0			8:01	8:11	8:21	8:31	8:41	8:50	9:00	9:10	9:20
402.5				8:08	8:18	8:28	8:38	8:48	8:57	9:07	9:17
405.0				8:06	8:16	8:25	8:35	8:45	8:54	9:04	9:14
407.5				8:03	8:13	8:23	8:32	8:42	8:52	9:01	9:11
410.0				8:01	8:10	8:20	8:30	8:39	8:49	8:58	9:08
412.5					8:08	8:17	8:27	8:36	8:46	8:56	9:05
415.0					8:05	8:15	8:24	8:34	8:43	8:53	9:02
417.5					8:03	8:12	8:22	8:31	8:40	8:50	8:59
420.0					8:00	8:10	8:19	8:28	8:38	8:47	8:57
422.5						8:07	8:16	8:26	8:35	8:44	8:54
425.0						8:05	8:14	8:23	8:33	8:42	8:51
427.5						8:02	8:11	8:21	8:30	8:39	8:48
430.0							8:09	8:18	8:27	8:36	8:46
432.5							8:07	8:16	8:25	8:34	8:43
435.0							8:04	8:13	8:22	8:31	8:40
437.5							8:02	8:11	8:20	8:29	8:38
440.0								8:08	8:17	8:26	8:35
442.5								8:06	8:15	8:24	8:33
445.0								8:04	8:13	8:21	8:30
447.5								8:01	8:10	8:19	8:28
450.0									8:08	8:17	8:25
452.5									8:05	8:14	8:23
455.0									8:03	8:12	8:20
457.5									8:01	8:10	8:18
460.0										8:07	8:16
462.5										8:05	8:13
465.0										8:03	8:11
467.5										8:00	8:09
470.0											8:07
472.5											8:04
475.0											8:02
477.5											8:00

	Weight	(in	pounds)							
Cal	255	260	265	270	275	280	285	290	295	300
170.0	20:49									
172.5	20:32									
175.0	20:16	20:38								
177.5	19:59	20:22	20:44							
180.0	19:44	20:06	20:28	20:49						
182.5	19:28	19:50	20:12	20:33						
185.0	19:14	19:35	19:56	20:17	20:39					
187.5	18:59	19:20	19:41	20:02	20:23	20:44				
190.0	18:45	19:06	19:26	19:47	20:08	20:29	20:49			
192.5	18:31	18:52	19:12	19:33	19:53	20:14	20:34			
195.0	18:18	18:38	18:58	19:19	19:39	19:59	20:19	20:39		
197.5	18:05	18:25	18:45	19:05	19:25	19:45	20:05	20:25	20:44	
200.0	17:52	18:12	18:32	18:51	19:11	19:31	19:50	20:10	20:30	20:49
202.5	17:40	17:59	18:19	18:38	18:58	19:17	19:36	19:56	20:15	20:35
205.0	17:28	17:47	18:06	18:25	18:45	19:04	19:23	19:42	20:01	20:21
207.5	17:16	17:35	17:54	18:13	18:32	18:51	19:10	19:29	19:48	20:07
210.0	17:04	17:23	17:42	18:01	18:19	18:38	18:57	19:16	19:34	19:53
212.5	16:53	17:12	17:30	17:49	18:07	18:26	18:44	19:03	19:21	19:40
215.0	16:42	17:00	17:19	17:37	17:55	18:14	18:32	18:50	19:09	19:27
217.5	16:31	16:49	17:08	17:26	17:44	18:02	18:20	18:38	18:56	19:14
220.0	16:21	16:39	16:57	17:15	17:32	17:50	18:08	18:26	18:44	19:02
222.5	16:11	16:28	16:46	17:04	17:21	17:39	17:57	18:15	18:32	18:50
225.0	16:01	16:18	16:36	16:53	17:11	17:28	17:46	18:03	18:21	18:38
227.5	15:51	16:08	16:25	16:43	16:60	17:17	17:35	17:52	18:09	18:27
230.0	15:41	15:58	16:15	16:33	16:50	17:07	17:24	17:41	17:58	18:15
232.5	15:32	15:49	16:06	16:23	16:40	16:56	17:13	17:30	17:47	18:04
235.0	15:23	15:39	15:56	16:13	16:30	16:46	17:03	17:20	17:37	17:53
237.5	15:14	15:30	15:47	16:03	16:20	16:36	16:53	17:10	17:26	17:43
240.0	15:05	15:21	15:38	15:54	16:10	16:27	16:43	16:60	17:16	17:32
242.5	14:56	15:12	15:29	15:45	16:01	16:17	16:34	16:50	17:06	17:22
245.0	14:48	15:04	15:20	15:36	15:52	16:08	16:24	16:40	16:56	17:12
247.5	14:39	14:55	15:11	15:27	15:43	15:59	16:15	16:31	16:47	17:03
250.0	14:31	14:47	15:03	15:19	15:34	15:50	16:06	16:22	16:37	16:53
252.5	14:23	14:39	14:54	15:10	15:26	15:41	15:57	16:12	16:28	16:44
255.0	14:15	14:31	14:46	15:02	15:17	15:33	15:48	16:04	16:19	16:35
257.5	14:08	14:23	14:38	14:54	15:09	15:24	15:40	15:55	16:10	16:26
260.0	14:00	14:15	14:31	14:46	15:01	15:16	15:31	15:46	16:02	16:17
262.5	13:53	14:08	14:23	14:38	14:53	15:08	15:23	15:38	15:53	16:08
265.0	13:46	14:01	14:15	14:30	14:45	15:00	15:15	15:30	15:45	15:60
267.5	13:39	13:53	14:08	14:23	14:38	14:52	15:07	15:22	15:36	15:51
270.0	13:32	13:46	14:01	14:15	14:30	14:45	14:59	15:14	15:28	15:43
272.5	13:25	13:39	13:54	14:08	14:23	14:37	14:52	15:06	15:21	15:35
275.0	13:18	13:33	13:47	14:01	14:15	14:30	14:44	14:58	15:13	15:27
277.5	13:12	13:26	13:40	13:54	14:08	14:23	14:37	14:51	15:05	15:19
280.0	13:05	13:19	13:33	13:47	14:01	14:15	14:30	14:44	14:58	15:12
282.5	12:59	13:13	13:27	13:41	13:55	14:09	14:22	14:36	14:50	15:04
285.0	12:53	13:06	13:20	13:34	13:48	14:02	14:15	14:29	14:43	14:57
287.5	12:46	13:00	13:14	13:28	13:41	13:55	14:09	14:22	14:36	14:50
290.0	12:40	12:54	13:08	13:21	13:35	13:48	14:02	14:15	14:29	14:43

	Weight	(in	pounds)							
Cal	255	260	265	270	275	280	285	290	295	300
292.5	12:34	12:48	13:01	13:15	13:28	13:42	13:55	14:09	14:22	14:36
295.0	12:29	12:42	12:55	13:09	13:22	13:35	13:49	14:02	14:15	14:29
297.5	12:23	12:36	12:49	13:03	13:16	13:29	13:42	13:56	14:09	14:22
300.0	12:17	12:30	12:44	12:57	13:10	13:23	13:36	13:49	14:02	14:15
302.5	12:12	12:25	12:38	12:51	13:04	13:17	13:30	13:43	13:56	14:09
305.0	12:06	12:19	12:32	12:45	12:58	13:11	13:24	13:37	13:50	14:03
307.5	12:01	12:14	12:27	12:39	12:52	13:05	13:18	13:31	13:43	13:56
310.0	11:56	12:08	12:21	12:34	12:47	12:59	13:12	13:25	13:37	13:50
312.5	11:51	12:03	12:16	12:28	12:41	12:54	13:06	13:19	13:31	13:44
315.0	11:45	11:58	12:10	12:23	12:35	12:48	13:00	13:13	13:25	13:38
317.5	11:40	11:53	12:05	12:18	12:30	12:42	12:55	13:07	13:20	13:32
320.0	11:35	11:48	12:00	12:12	12:25	12:37	12:49	13:02	13:14	13:26
322.5	11:31	11:43	11:55	12:07	12:19	12:32	12:44	12:56	13:08	13:21
325.0	11:26	11:38	11:50	12:02	12:14	12:26	12:39	12:51	13:03	13:15
327.5	11:21	11:33	11:45	11:57	12:09	12:21	12:33	12:45	12:57	13:09
330.0	11:16	11:28	11:40	11:52	12:04	12:16	12:28	12:40	12:52	13:04
332.5	11:12	11:24	11:36	11:47	11:59	12:11	12:23	12:35	12:47	12:58
335.0	11:07	11:19	11:31	11:43	11:54	12:06	12:18	12:30	12:41	12:53
337.5	11:03	11:15	11:26	11:38	11:50	12:01	12:13	12:25	12:36	12:48
340.0	10:58	11:10	11:22	11:33	11:45	11:56	12:08	12:20	12:31	12:43
342.5	10:54	11:06	11:17	11:29	11:40	11:52	12:03	12:15	12:26	12:38
345.0	10:50	11:01	11:13	11:24	11:36	11:47	11:58	12:10	12:21	12:33
347.5	10:46	10:57	11:08	11:20	11:31	11:42	11:54	12:05	12:16	12:28
350.0	10:42	10:53	11:04	11:15	11:27	11:38	11:49	12:00	12:12	12:23
352.5	10:38	10:49	10:60	11:11	11:22	11:33	11:45	11:56	12:07	12:18
355.0	10:34	10:45	10:56	11:07	11:18	11:29	11:40	11:51	12:02	12:13
357.5	10:30	10:41	10:52	11:03	11:14	11:25	11:36	11:47	11:58	12:09
360.0	10:26	10:37	10:48	10:58	11:09	11:20	11:31	11:42	11:53	12:04
362.5	10:22	10:33	10:44	10:54	11:05	11:16	11:27	11:38	11:49	11:60
365.0	10:18	10:29	10:40	10:50	11:01	11:12	11:23	11:34	11:44	11:55
367.5	10:14	10:25	10:36	10:46	10:57	11:08	11:19	11:29	11:40	11:51
370.0	10:11	10:21	10:32	10:43	10:53	11:04	11:14	11:25	11:36	11:46
372.5	10:07	10:18	10:28	10:39	10:49	10:60	11:10	11:21	11:32	11:42
375.0	10:03	10:14	10:24	10:35	10:45	10:56	11:06	11:17	11:27	11:38
377.5	9:60	10:10	10:21	10:31	10:42	10:52	11:02	11:13	11:23	11:34
380.0	9:56	10:07	10:17	10:27	10:38	10:48	10:58	11:09	11:19	11:30
382.5	9:53	10:03	10:13	10:24	10:34	10:44	10:55	11:05	11:15	11:26
385.0	9:49	9:60	10:10	10:20	10:30	10:41	10:51	11:01	11:11	11:22
387.5	9:46	9:56	10:06	10:17	10:27	10:37	10:47	10:57	11:07	11:18
390.0	9:43	9:53	10:03	10:13	10:23	10:33	10:43	10:53	11:04	11:14
392.5	9:39	9:49	9:60	10:10	10:20	10:30	10:40	10:50	10:60	11:10
395.0	9:36	9:46	9:56	10:06	10:16	10:26	10:36	10:46	10:56	11:06
397.5	9:33	9:43	9:53	10:03	10:13	10:23	10:32	10:42	10:52	11:02
400.0	9:30	9:40	9:50	9:59	10:09	10:19	10:29	10:39	10:49	10:58
402.5	9:27	9:37	9:46	9:56	10:06	10:16	10:25	10:35	10:45	10:55
405.0	9:24	9:33	9:43	9:53	10:03	10:12	10:22	10:32	10:41	10:51
407.5	9:21	9:30	9:40	9:50	9:59	10:09	10:19	10:28	10:38	10:48
410.0	9:18	9:27	9:37	9:46	9:56	10:06	10:15	10:25	10:34	10:44
412.5	9:15	9:24	9:34	9:43	9:53	10:02	10:12	10:21	10:31	10:41

	Weight	(in	pounds)							
Cal	255	260	265	270	275	280	285	290	295	300
415.0	9:12	9:21	9:31	9:40	9:50	9:59	10:09	10:18	10:28	10:37
417.5	9:09	9:18	9:28	9:37	9:47	9:56	10:05	10:15	10:24	10:34
420.0	9:06	9:15	9:25	9:34	9:43	9:53	10:02	10:12	10:21	10:30
422.5	9:03	9:12	9:22	9:31	9:40	9:50	9:59	10:08	10:18	10:27
425.0	9:00	9:10	9:19	9:28	9:37	9:47	9:56	10:05	10:14	10:24
427.5	8:58	9:07	9:16	9:25	9:34	9:44	9:53	10:02	10:11	10:20
430.0	8:55	9:04	9:13	9:22	9:31	9:41	9:50	9:59	10:08	10:17
432.5	8:52	9:01	9:10	9:19	9:29	9:38	9:47	9:56	10:05	10:14
435.0	8:49	8:58	9:08	9:17	9:26	9:35	9:44	9:53	10:02	10:11
437.5	8:47	8:56	9:05	9:14	9:23	9:32	9:41	9:50	9:59	10:08
440.0	8:44	8:53	9:02	9:11	9:20	9:29	9:38	9:47	9:56	10:05
442.5	8:42	8:51	8:59	9:08	9:17	9:26	9:35	9:44	9:53	10:02
445.0	8:39	8:48	8:57	9:06	9:14	9:23	9:32	9:41	9:50	9:59
447.5	8:37	8:45	8:54	9:03	9:12	9:21	9:29	9:38	9:47	9:56
450.0	8:34	8:43	8:52	9:00	9:09	9:18	9:27	9:35	9:44	9:53
452.5	8:32	8:40	8:49	8:58	9:06	9:15	9:24	9:33	9:41	9:50
455.0	8:29	8:38	8:46	8:55	9:04	9:12	9:21	9:30	9:38	9:47
457.5	8:27	8:35	8:44	8:53	9:01	9:10	9:18	9:27	9:36	9:44
460.0	8:24	8:33	8:41	8:50	8:59	9:07	9:16	9:24	9:33	9:41
462.5	8:22	8:30	8:39	8:48	8:56	9:05	9:13	9:22	9:30	9:39
465.0	8:20	8:28	8:37	8:45	8:54	9:02	9:10	9:19	9:27	9:36
467.5	8:17	8:26	8:34	8:43	8:51	8:59	9:08	9:16	9:25	9:33
470.0	8:15	8:23	8:32	8:40	8:49	8:57	9:05	9:14	9:22	9:30
472.5	8:13	8:21	8:29	8:38	8:46	8:54	9:03	9:11	9:19	9:28
475.0	8:11	8:19	8:27	8:35	8:44	8:52	9:00	9:09	9:17	9:25
477.5	8:08	8:17	8:25	8:33	8:41	8:50	8:58	9:06	9:14	9:23
480.0	8:06	8:14	8:23	8:31	8:39	8:47	8:55	9:04	9:12	9:20
482.5	8:04	8:12	8:20	8:28	8:37	8:45	8:53	9:01	9:09	9:17
485.0	8:02	8:10	8:18	8:26	8:34	8:42	8:51	8:59	9:07	9:15
487.5	8:00	8:08	8:16	8:24	8:32	8:40	8:48	8:56	9:04	9:12
490.0		8:06	8:14	8:22	8:30	8:38	8:46	8:54	9:02	9:10
492.5		8:04	8:12	8:20	8:28	8:36	8:44	8:52	8:60	9:08
495.0		8:02	8:09	8:17	8:25	8:33	8:41	8:49	8:57	9:05
497.5		8:00	8:07	8:15	8:23	8:31	8:39	8:47	8:55	9:03
500.0			8:05	8:13	8:21	8:29	8:37	8:45	8:52	9:00
502.5			8:03	8:11	8:19	8:27	8:35	8:43	8:50	8:58
505.0			8:01	8:09	8:17	8:25	8:33	8:40	8:48	8:56
507.5				8:07	8:15	8:23	8:30	8:38	8:46	8:54
510.0				8:05	8:13	8:21	8:28	8:36	8:44	8:51
512.5				8:03	8:11	8:18	8:26	8:34	8:42	8:49
515.0				8:01	8:09	8:16	8:24	8:32	8:39	8:47
517.5						8:14	8:22	8:30	8:37	8:45
520.0						8:12	8:20	8:27	8:35	8:43
522.5						8:10	8:18	8:25	8:33	8:40
525.0						8:08	8:16	8:23	8:31	8:38
527.5						8:06	8:14	8:21	8:29	8:36
530.0						8:04	8:12	8:19	8:27	8:34
532.5						8:02	8:10	8:17	8:24	8:32
535.0						8:00	8:08	8:15	8:22	8:30

537.5	8:06	8:13	8:20	8:28
540.0	8:04	8:11	8:18	8:26
542.5	8:02	8:09	8:16	8:24
545.0	8:00	8:07	8:14	8:22
547.5		8:05	8:13	8:20
550.0		8:03	8:11	8:18
552.5		8:01	8:09	8:16
555.0			8:07	8:14
557.5			8:05	8:12
560.0			8:03	8:10
562.5			8:01	8:08
565.0				8:06
567.5				8:05
570.0				8:03
572.5				8:01

Appendix E. Tables to Convert CT 9500 HR Performance to Run Time Equivalent for Women

The following table applies Equation 7 to convert the calorie expenditure reported by the CT 9500 HR to an equivalent run time for women. The table gives run times by subject weight. Two dimensions are necessary because the energy expenditure required for running a given distance increases with weight.

Interpolation is necessary when using the table to obtain times for some combinations of weight and energy expenditure. The tabled values apply to weights between 90 and 300 pounds in 5-pound increments. Levels of energy expenditure have been tabled 2.5 calorie increments. The levels are close enough together to permit accurate linear interpolation between tabled values for test subjects whose weight/energy expenditure rate combination is not listed in the table provided the combination is within the range of tabled values.

The tabled values were constrained to match the performance standards provided in the Physical Readiness Test. The tables provide conversions for the energy expenditures that convert to the minimum and maximum times in the PRT tables for women. The minimum time in those tables is the time that must be achieved to be classified as “Outstanding/High” in the 17-21 age group. That time currently is 9:29. Therefore, the highest energy expenditure that has been tabled for each weight is the first value that converted to a time less than 9:29 min. The maximum time in the PRT tables for women is the time that would be required for a woman 65 years of age or older to avoid failing the test. That time currently is 20:52 min. A woman 65 years of age or older who achieved this time would be classified as “Probationary.” If her time were even a second slower she would be a PRT failure. The lowest energy expenditure rate in the table for each weight therefore was the first 2.5-calorie increment that converted to a time in excess of 20:52 min.

Weight in Pounds

Cal.	90	95	100	105	110	115	120	125	130	135	140
62.5	21:10										
65.0	20:26	21:27									
67.5	19:46	20:44									
70.0	19:08	20:04	21:01								
72.5	18:33	19:27	20:22	21:16							
75.0	18:01	18:53	19:46	20:38	21:31						
77.5	17:30	18:21	19:12	20:03	20:53						
80.0	17:01	17:51	18:40	19:29	20:18	21:08					
82.5	16:35	17:22	18:10	18:58	19:46	20:33	21:21				
85.0	16:09	16:56	17:42	18:28	19:15	20:01	20:47				
87.5	15:45	16:30	17:15	18:01	18:46	19:31	20:16	21:01			
90.0	15:23	16:07	16:50	17:34	18:18	19:02	19:46	20:29	21:13		
92.5	15:02	15:44	16:27	17:09	17:52	18:35	19:17	19:60	20:42	21:25	
95.0	14:41	15:23	16:04	16:46	17:27	18:09	18:50	19:32	20:13	20:55	
97.5	14:22	15:03	15:43	16:24	17:04	17:44	18:25	19:05	19:46	20:26	21:06
100.0	14:04	14:44	15:23	16:02	16:42	17:21	18:01	18:40	19:19	19:59	20:38
102.5	13:47	14:25	15:04	15:42	16:21	16:59	17:37	18:16	18:54	19:33	20:11
105.0	13:30	14:08	14:45	15:23	16:00	16:38	17:15	17:53	18:31	19:08	19:46
107.5	13:15	13:51	14:28	15:05	15:41	16:18	16:55	17:31	18:08	18:44	19:21
110.0	12:60	13:35	14:11	14:47	15:23	15:59	16:35	17:10	17:46	18:22	18:58
112.5	12:45	13:20	13:55	14:30	15:05	15:40	16:15	16:50	17:25	18:01	18:36
115.0	12:32	13:06	13:40	14:14	14:49	15:23	15:57	16:31	17:06	17:40	18:14
117.5	12:19	12:52	13:26	13:59	14:33	15:06	15:40	16:13	16:47	17:20	17:54
120.0	12:06	12:39	13:12	13:44	14:17	14:50	15:23	15:56	16:29	17:01	17:34
122.5	11:54	12:26	12:58	13:30	14:03	14:35	15:07	15:39	16:11	16:43	17:15
125.0	11:42	12:14	12:45	13:17	13:48	14:20	14:51	15:23	15:54	16:26	16:57
127.5	11:31	12:02	12:33	13:04	13:35	14:06	14:37	15:07	15:38	16:09	16:40
130.0	11:20	11:51	12:21	12:51	13:22	13:52	14:22	14:53	15:23	15:53	16:24
132.5	11:10	11:40	12:10	12:39	13:09	13:39	14:09	14:38	15:08	15:38	16:08
135.0	11:00	11:29	11:59	12:28	12:57	13:26	13:55	14:25	14:54	15:23	15:52
137.5	10:51	11:19	11:48	12:17	12:45	13:14	13:43	14:11	14:40	15:09	15:37
140.0	10:42	11:10	11:38	12:06	12:34	13:02	13:30	13:58	14:27	14:55	15:23
142.5	10:33	11:00	11:28	11:56	12:23	12:51	13:19	13:46	14:14	14:41	15:09
145.0	10:24	10:51	11:18	11:46	12:13	12:40	13:07	13:34	14:01	14:29	14:56
147.5	10:16	10:42	11:09	11:36	12:03	12:29	12:56	13:23	13:49	14:16	14:43
150.0	10:08	10:34	11:00	11:27	11:53	12:19	12:45	13:12	13:38	14:04	14:30
152.5	10:00	10:26	10:52	11:18	11:43	12:09	12:35	13:01	13:27	13:53	14:18
155.0	9:53	10:18	10:43	11:09	11:34	11:60	12:25	12:50	13:16	13:41	14:07
157.5	9:45	10:10	10:35	11:00	11:25	11:50	12:15	12:40	13:05	13:30	13:55
160.0	9:38	10:03	10:27	10:52	11:17	11:41	12:06	12:31	12:55	13:20	13:44
162.5	9:31	9:56	10:20	10:44	11:08	11:33	11:57	12:21	12:45	13:10	13:34
165.0	9:25	9:49	10:13	10:36	11:00	11:24	11:48	12:12	12:36	12:60	13:24
167.5		9:42	10:05	10:29	10:52	11:16	11:39	12:03	12:27	12:50	13:14
170.0		9:35	9:58	10:22	10:45	11:08	11:31	11:54	12:18	12:41	13:04
172.5		9:29	9:52	10:15	10:37	11:00	11:23	11:46	12:09	12:32	12:54
175.0		9:23	9:45	10:08	10:30	10:53	11:15	11:38	12:00	12:23	12:45
177.5			9:39	10:01	10:23	10:45	11:08	11:30	11:52	12:14	12:36
180.0			9:33	9:55	10:17	10:38	11:00	11:22	11:44	12:06	12:28
182.5			9:27	9:48	10:10	10:31	10:53	11:15	11:36	11:58	12:19
185.0				9:42	10:03	10:25	10:46	11:07	11:29	11:50	12:11
187.5				9:36	9:57	10:18	10:39	11:00	11:21	11:42	12:03
190.0				9:30	9:51	10:12	10:33	10:53	11:14	11:35	11:56
192.5				9:25	9:45	10:06	10:26	10:47	11:07	11:28	11:48
195.0					9:39	9:60	10:20	10:40	11:00	11:20	11:41

Weight in Pounds

Cal:	90	95	100	105	110	115	120	125	130	135	140
197.5					9:34	9:54	10:14	10:34	10:54	11:14	11:34
200.0					9:28	9:48	10:08	10:27	10:47	11:07	11:27
202.5						9:42	10:02	10:21	10:41	11:00	11:20
205.0						9:37	9:56	10:15	10:35	10:54	11:13
207.5						9:32	9:51	10:10	10:29	10:48	11:07
210.0						9:26	9:45	10:04	10:23	10:42	11:00
212.5							9:40	9:58	10:17	10:36	10:54
215.0							9:35	9:53	10:11	10:30	10:48
217.5							9:30	9:48	10:06	10:24	10:42
220.0							9:25	9:43	10:01	10:18	10:36
222.5								9:38	9:55	10:13	10:31
225.0								9:33	9:50	10:08	10:25
227.5								9:28	9:45	10:03	10:20
230.0									9:40	9:57	10:15
232.5									9:36	9:53	10:09
235.0									9:31	9:48	10:04
237.5										9:43	9:59
240.0										9:38	9:55
242.5										9:34	9:50
245.0										9:29	9:45
247.5										9:25	9:41
250.0											9:36
252.5											9:32
255.0											9:28

	Weight in Pounds										
Cal:	145	150	155	160	165	170	175	180	185	190	195
100.0	21:17										
102.5	20:50										
105.0	20:23	21:01									
107.5	19:58	20:34	21:11								
110.0	19:34	20:09	20:45	21:21							
112.5	19:11	19:46	20:21	20:56							
115.0	18:48	19:23	19:57	20:31	21:05						
117.5	18:27	19:01	19:34	20:08	20:41	21:15					
120.0	18:07	18:40	19:13	19:46	20:18	20:51					
122.5	17:48	18:20	18:52	19:24	19:56	20:28	21:01				
125.0	17:29	18:01	18:32	19:04	19:35	20:07	20:38	21:10			
127.5	17:11	17:42	18:13	18:44	19:15	19:46	20:16	20:47	21:18		
130.0	16:54	17:24	17:54	18:25	18:55	19:25	19:56	20:26	20:56		
132.5	16:37	17:07	17:37	18:06	18:36	19:06	19:36	20:05	20:35	21:05	
135.0	16:21	16:50	17:20	17:49	18:18	18:47	19:16	19:46	20:15	20:44	21:13
137.5	16:06	16:35	17:03	17:32	18:01	18:29	18:58	19:26	19:55	20:24	20:52
140.0	15:51	16:19	16:47	17:15	17:44	18:12	18:40	19:08	19:36	20:04	20:32
142.5	15:37	16:04	16:32	16:60	17:27	17:55	18:23	18:50	19:18	19:46	20:13
145.0	15:23	15:50	16:17	16:44	17:12	17:39	18:06	18:33	19:00	19:27	19:55
147.5	15:10	15:36	16:03	16:30	16:56	17:23	17:50	18:17	18:43	19:10	19:37
150.0	14:57	15:23	15:49	16:15	16:42	17:08	17:34	18:01	18:27	18:53	19:19
152.5	14:44	15:10	15:36	16:02	16:28	16:53	17:19	17:45	18:11	18:37	19:03
155.0	14:32	14:58	15:23	15:48	16:14	16:39	17:05	17:30	17:55	18:21	18:46
157.5	14:20	14:45	15:10	15:35	16:00	16:25	16:50	17:15	17:40	18:06	18:31
160.0	14:09	14:34	14:58	15:23	15:48	16:12	16:37	17:01	17:26	17:51	18:15
162.5	13:58	14:22	14:47	15:11	15:35	15:59	16:24	16:48	17:12	17:36	18:01
165.0	13:47	14:11	14:35	14:59	15:23	15:47	16:11	16:35	16:58	17:22	17:46
167.5	13:37	14:01	14:24	14:48	15:11	15:35	15:58	16:22	16:45	17:09	17:32
170.0	13:27	13:50	14:13	14:37	14:60	15:23	15:46	16:09	16:32	16:56	17:19
172.5	13:17	13:40	14:03	14:26	14:49	15:11	15:34	15:57	16:20	16:43	17:06
175.0	13:08	13:30	13:53	14:15	14:38	15:00	15:23	15:45	16:08	16:30	16:53
177.5	12:59	13:21	13:43	14:05	14:27	14:50	15:12	15:34	15:56	16:18	16:41
180.0	12:50	13:12	13:33	13:55	14:17	14:39	15:01	15:23	15:45	16:07	16:29
182.5	12:41	13:03	13:24	13:46	14:07	14:29	14:51	15:12	15:34	15:55	16:17
185.0	12:33	12:54	13:15	13:36	13:58	14:19	14:40	15:02	15:23	15:44	16:06
187.5	12:24	12:45	13:06	13:27	13:48	14:09	14:30	14:51	15:12	15:33	15:54
190.0	12:16	12:37	12:58	13:19	13:39	13:60	14:21	14:41	15:02	15:23	15:44
192.5	12:08	12:29	12:49	13:10	13:30	13:51	14:11	14:32	14:52	15:13	15:33
195.0	12:01	12:21	12:41	13:01	13:22	13:42	14:02	14:22	14:43	15:03	15:23
197.5	11:53	12:13	12:33	12:53	13:13	13:33	13:53	14:13	14:33	14:53	15:13
200.0	11:46	12:06	12:26	12:45	13:05	13:25	13:44	14:04	14:24	14:44	15:03
202.5	11:39	11:59	12:18	12:38	12:57	13:16	13:36	13:55	14:15	14:34	14:54
205.0	11:32	11:52	12:11	12:30	12:49	13:08	13:28	13:47	14:06	14:25	14:44
207.5	11:26	11:45	12:04	12:23	12:42	13:01	13:20	13:38	13:57	14:16	14:35
210.0	11:19	11:38	11:57	12:15	12:34	12:53	13:12	13:30	13:49	14:08	14:27
212.5	11:13	11:31	11:50	12:08	12:27	12:45	13:04	13:22	13:41	13:59	14:18
215.0	11:06	11:25	11:43	12:01	12:20	12:38	12:56	13:15	13:33	13:51	14:10
217.5	11:00	11:18	11:37	11:55	12:13	12:31	12:49	13:07	13:25	13:43	14:01
220.0	10:54	11:12	11:30	11:48	12:06	12:24	12:42	12:60	13:18	13:35	13:53
222.5	10:48	11:06	11:24	11:42	11:59	12:17	12:35	12:52	13:10	13:28	13:46
225.0	10:43	11:00	11:18	11:35	11:53	12:10	12:28	12:45	13:03	13:20	13:38
227.5	10:37	10:55	11:12	11:29	11:46	12:04	12:21	12:38	12:56	13:13	13:30
230.0	10:32	10:49	11:06	11:23	11:40	11:57	12:15	12:32	12:49	13:06	13:23

					Weight in Pounds						
Cal:	145	150	155	160	165	170	175	180	185	190	195
232.5	10:26	10:43	11:00	11:17	11:34	11:51	12:08	12:25	12:42	12:59	13:16
235.0	10:21	10:38	10:55	11:11	11:28	11:45	12:02	12:19	12:35	12:52	13:09
237.5	10:16	10:33	10:49	11:06	11:22	11:39	11:56	12:12	12:29	12:45	13:02
240.0	10:11	10:27	10:44	11:00	11:17	11:33	11:50	12:06	12:22	12:39	12:55
242.5	10:06	10:22	10:39	10:55	11:11	11:27	11:44	11:60	12:16	12:32	12:49
245.0	10:01	10:17	10:33	10:50	11:06	11:22	11:38	11:54	12:10	12:26	12:42
247.5	9:57	10:13	10:28	10:44	11:00	11:16	11:32	11:48	12:04	12:20	12:36
250.0	9:52	10:08	10:24	10:39	10:55	11:11	11:27	11:42	11:58	12:14	12:30
252.5	9:47	10:03	10:19	10:34	10:50	11:05	11:21	11:37	11:52	12:08	12:23
255.0	9:43	9:58	10:14	10:29	10:45	11:00	11:16	11:31	11:47	12:02	12:18
257.5	9:39	9:54	10:09	10:25	10:40	10:55	11:10	11:26	11:41	11:56	12:12
260.0	9:34	9:50	10:05	10:20	10:35	10:50	11:05	11:20	11:36	11:51	12:06
262.5	9:30	9:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	12:00
265.0	9:26	9:41	9:56	10:11	10:26	10:40	10:55	11:10	11:25	11:40	11:55
267.5		9:37	9:52	10:06	10:21	10:36	10:50	11:05	11:20	11:35	11:49
270.0		9:33	9:47	10:02	10:17	10:31	10:46	11:00	11:15	11:29	11:44
272.5		9:29	9:43	9:58	10:12	10:27	10:41	10:55	11:10	11:24	11:39
275.0			9:39	9:53	10:08	10:22	10:36	10:51	11:05	11:19	11:34
277.5			9:35	9:49	10:03	10:18	10:32	10:46	11:00	11:14	11:29
280.0			9:31	9:45	9:59	10:13	10:27	10:42	10:56	11:10	11:24
282.5			9:27	9:41	9:55	10:09	10:23	10:37	10:51	11:05	11:19
285.0				9:37	9:51	10:05	10:19	10:33	10:46	11:00	11:14
287.5				9:33	9:47	10:01	10:15	10:28	10:42	10:56	11:09
290.0				9:30	9:43	9:57	10:10	10:24	10:38	10:51	11:05
292.5				9:26	9:39	9:53	10:06	10:20	10:33	10:47	11:00
295.0					9:36	9:49	10:02	10:16	10:29	10:42	10:56
297.5					9:32	9:45	9:58	10:12	10:25	10:38	10:51
300.0					9:28	9:41	9:55	10:08	10:21	10:34	10:47
302.5						9:38	9:51	10:04	10:17	10:30	10:43
305.0						9:34	9:47	10:00	10:13	10:26	10:39
307.5						9:31	9:43	9:56	10:09	10:22	10:35
310.0						9:27	9:40	9:53	10:05	10:18	10:31
312.5							9:36	9:49	10:01	10:14	10:27
315.0							9:33	9:45	9:58	10:10	10:23
317.5							9:29	9:42	9:54	10:07	10:19
320.0							9:26	9:38	9:51	10:03	10:15
322.5								9:35	9:47	9:59	10:11
325.0								9:31	9:44	9:56	10:08
327.5								9:28	9:40	9:52	10:04
330.0									9:37	9:49	10:01
332.5									9:33	9:45	9:57
335.0									9:30	9:42	9:54
337.5									9:27	9:39	9:50
340.0										9:35	9:47
342.5										9:32	9:44
345.0										9:29	9:40
347.5										9:26	9:37
350.0											9:34
352.5											9:31
355.0											9:28

Weight in Pounds

Cal:	200	205	210	215	220	225	230	235	240	245	250
140.0	21:01										
142.5	20:41	21:08									
145.0	20:22	20:49	21:16								
147.5	20:03	20:30	20:57								
150.0	19:46	20:12	20:38	21:04							
152.5	19:28	19:54	20:20	20:46	21:12						
155.0	19:12	19:37	20:03	20:28	20:53						
157.5	18:56	19:21	19:46	20:11	20:36	21:01					
160.0	18:40	19:05	19:29	19:54	20:18	20:43	21:08				
162.5	18:25	18:49	19:13	19:37	20:02	20:26	20:50	21:14			
165.0	18:10	18:34	18:58	19:22	19:46	20:09	20:33	20:57			
167.5	17:56	18:19	18:43	19:06	19:30	19:53	20:17	20:40	21:04		
170.0	17:42	18:05	18:28	18:51	19:15	19:38	20:01	20:24	20:47	21:11	
172.5	17:29	17:51	18:14	18:37	18:60	19:23	19:46	20:08	20:31	20:54	
175.0	17:15	17:38	18:01	18:23	18:46	19:08	19:31	19:53	20:16	20:38	21:01
177.5	17:03	17:25	17:47	18:09	18:32	18:54	19:16	19:38	20:00	20:23	20:45
180.0	16:50	17:12	17:34	17:56	18:18	18:40	19:02	19:24	19:46	20:07	20:29
182.5	16:38	17:00	17:22	17:43	18:05	18:26	18:48	19:10	19:31	19:53	20:14
185.0	16:27	16:48	17:09	17:31	17:52	18:13	18:35	18:56	19:17	19:38	19:60
187.5	16:15	16:36	16:57	17:18	17:39	18:01	18:22	18:43	19:04	19:25	19:46
190.0	16:04	16:25	16:46	17:07	17:27	17:48	18:09	18:30	18:50	19:11	19:32
192.5	15:54	16:14	16:35	16:55	17:15	17:36	17:56	18:17	18:37	18:58	19:18
195.0	15:43	16:03	16:24	16:44	17:04	17:24	17:44	18:05	18:25	18:45	19:05
197.5	15:33	15:53	16:13	16:33	16:53	17:13	17:33	17:53	18:12	18:32	18:52
200.0	15:23	15:43	16:02	16:22	16:42	17:01	17:21	17:41	18:01	18:20	18:40
202.5	15:13	15:33	15:52	16:12	16:31	16:50	17:10	17:29	17:49	18:08	18:28
205.0	15:04	15:23	15:42	16:01	16:21	16:40	16:59	17:18	17:37	17:57	18:16
207.5	14:54	15:13	15:32	15:51	16:10	16:29	16:48	17:07	17:26	17:45	18:04
210.0	14:45	15:04	15:23	15:42	16:00	16:19	16:38	16:57	17:15	17:34	17:53
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215.0	14:28	14:46	15:05	15:23	15:41	15:60	16:18	16:36	16:55	17:13	17:31
217.5	14:20	14:38	14:56	15:14	15:32	15:50	16:08	16:26	16:44	17:03	17:21
220.0	14:11	14:29	14:47	15:05	15:23	15:41	15:59	16:17	16:35	16:52	17:10
222.5	14:03	14:21	14:39	14:56	15:14	15:32	15:49	16:07	16:25	16:43	17:00
225.0	13:55	14:13	14:30	14:48	15:05	15:23	15:40	15:58	16:15	16:33	16:50
227.5	13:48	14:05	14:22	14:40	14:57	15:14	15:32	15:49	16:06	16:24	16:41
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232.5	13:33	13:50	14:07	14:24	14:41	14:58	15:14	15:31	15:48	16:05	16:22
235.0	13:26	13:42	13:59	14:16	14:33	14:49	15:06	15:23	15:40	15:56	16:13
237.5	13:19	13:35	13:52	14:08	14:25	14:41	14:58	15:15	15:31	15:48	16:04
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242.5	13:05	13:21	13:37	13:54	14:10	14:26	14:42	14:59	15:15	15:31	15:47
245.0	12:58	13:14	13:30	13:46	14:03	14:19	14:35	14:51	15:07	15:23	15:39
247.5	12:52	13:08	13:24	13:39	13:55	14:11	14:27	14:43	14:59	15:15	15:31
250.0	12:45	13:01	13:17	13:33	13:48	14:04	14:20	14:36	14:51	15:07	15:23
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255.0	12:33	12:48	13:04	13:19	13:35	13:50	14:06	14:21	14:37	14:52	15:07
257.5	12:27	12:42	12:58	13:13	13:28	13:43	13:59	14:14	14:29	14:45	14:60
260.0	12:21	12:36	12:51	13:07	13:22	13:37	13:52	14:07	14:22	14:37	14:53
262.5	12:15	12:30	12:45	13:00	13:15	13:30	13:45	14:00	14:15	14:30	14:45
265.0	12:10	12:25	12:39	12:54	13:09	13:24	13:39	13:54	14:09	14:23	14:38
267.5	12:04	12:19	12:34	12:48	13:03	13:18	13:32	13:47	14:02	14:17	14:31
270.0	11:59	12:13	12:28	12:42	12:57	13:12	13:26	13:41	13:55	14:10	14:25

Weight in Pounds

Cal:	200	205	210	215	220	225	230	235	240	245	250
272.5	11:53	12:08	12:22	12:37	12:51	13:06	13:20	13:34	13:49	14:03	14:18
275.0	11:48	12:02	12:17	12:31	12:45	12:60	13:14	13:28	13:43	13:57	14:11
277.5	11:43	11:57	12:11	12:25	12:40	12:54	13:08	13:22	13:36	13:51	14:05
280.0	11:38	11:52	12:06	12:20	12:34	12:48	13:02	13:16	13:30	13:44	13:58
282.5	11:33	11:47	12:01	12:15	12:29	12:43	12:56	13:10	13:24	13:38	13:52
285.0	11:28	11:42	11:56	12:09	12:23	12:37	12:51	13:05	13:19	13:32	13:46
287.5	11:23	11:37	11:51	12:04	12:18	12:32	12:45	12:59	13:13	13:26	13:40
290.0	11:18	11:32	11:46	11:59	12:13	12:26	12:40	12:53	13:07	13:21	13:34
292.5	11:14	11:27	11:41	11:54	12:08	12:21	12:35	12:48	13:01	13:15	13:28
295.0	11:09	11:23	11:36	11:49	12:03	12:16	12:29	12:43	12:56	13:09	13:23
297.5	11:05	11:18	11:31	11:44	11:58	12:11	12:24	12:37	12:51	13:04	13:17
300.0	11:00	11:13	11:27	11:40	11:53	12:06	12:19	12:32	12:45	12:58	13:12
302.5	10:56	11:09	11:22	11:35	11:48	12:01	12:14	12:27	12:40	12:53	13:06
305.0	10:52	11:05	11:18	11:30	11:43	11:56	12:09	12:22	12:35	12:48	13:01
307.5	10:47	11:00	11:13	11:26	11:39	11:52	12:04	12:17	12:30	12:43	12:56
310.0	10:43	10:56	11:09	11:21	11:34	11:47	11:60	12:12	12:25	12:38	12:50
312.5	10:39	10:52	11:04	11:17	11:30	11:42	11:55	12:08	12:20	12:33	12:45
315.0	10:35	10:48	11:00	11:13	11:25	11:38	11:50	12:03	12:15	12:28	12:40
317.5	10:31	10:44	10:56	11:09	11:21	11:33	11:46	11:58	12:11	12:23	12:35
320.0	10:27	10:40	10:52	11:04	11:17	11:29	11:41	11:54	12:06	12:18	12:31
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340.0	9:58	10:10	10:22	10:33	10:45	10:56	11:08	11:20	11:31	11:43	11:54
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345.0	9:52	10:03	10:15	10:26	10:37	10:49	11:00	11:12	11:23	11:35	11:46
347.5	9:48	9:60	10:11	10:22	10:34	10:45	10:56	11:08	11:19	11:31	11:42
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355.0	9:39	9:50	10:01	10:12	10:23	10:34	10:45	10:57	11:08	11:19	11:30
357.5	9:36	9:47	9:58	10:09	10:20	10:31	10:42	10:53	11:04	11:15	11:26
360.0	9:33	9:44	9:55	10:06	10:17	10:27	10:38	10:49	11:00	11:11	11:22
362.5	9:30	9:41	9:51	10:02	10:13	10:24	10:35	10:46	10:57	11:08	11:18
365.0	9:27	9:38	9:48	9:59	10:10	10:21	10:31	10:42	10:53	11:04	11:15
367.5		9:35	9:45	9:56	10:07	10:17	10:28	10:39	10:50	11:00	11:11
370.0		9:32	9:42	9:53	10:03	10:14	10:25	10:35	10:46	10:57	11:07
372.5		9:29	9:39	9:50	10:00	10:11	10:21	10:32	10:43	10:53	11:04
375.0		9:26	9:36	9:47	9:57	10:08	10:18	10:29	10:39	10:50	11:00
377.5			9:33	9:44	9:54	10:05	10:15	10:25	10:36	10:46	10:57
380.0			9:30	9:41	9:51	10:02	10:12	10:22	10:33	10:43	10:53
382.5			9:28	9:38	9:48	9:58	10:09	10:19	10:29	10:40	10:50
385.0			9:25	9:35	9:45	9:55	10:06	10:16	10:26	10:36	10:47
387.5				9:32	9:42	9:53	10:03	10:13	10:23	10:33	10:43
390.0				9:29	9:39	9:50	9:60	10:10	10:20	10:30	10:40
392.5				9:27	9:37	9:47	9:57	10:07	10:17	10:27	10:37
395.0					9:34	9:44	9:54	10:04	10:14	10:24	10:34
397.5					9:31	9:41	9:51	10:01	10:11	10:21	10:31
400.0					9:28	9:38	9:48	9:58	10:08	10:18	10:27
402.5					9:26	9:35	9:45	9:55	10:05	10:15	10:24
405.0						9:33	9:42	9:52	10:02	10:12	10:21

Weight in Pounds

Cal:	200	205	210	215	220	225	230	235	240	245	250
407.5						9:30	9:40	9:49	9:59	10:09	10:18
410.0						9:27	9:37	9:47	9:56	10:06	10:15
412.5						9:25	9:34	9:44	9:53	10:03	10:13
415.0							9:32	9:41	9:51	10:00	10:10
417.5							9:29	9:38	9:48	9:57	10:07
420.0							9:26	9:36	9:45	9:55	10:04
422.5								9:33	9:43	9:52	10:01
425.0								9:31	9:40	9:49	9:58
427.5								9:28	9:37	9:47	9:56
430.0								9:26	9:35	9:44	9:53
432.5									9:32	9:41	9:50
435.0									9:30	9:39	9:48
437.5									9:27	9:36	9:45
440.0									9:25	9:34	9:43
442.5										9:31	9:40
445.0										9:29	9:38
447.5										9:26	9:35
450.0											9:33
452.5											9:30
455.0											9:28
457.5											9:26

	Weight in Pounds									
Cal:	255	260	265	270	275	280	285	290	295	300
177.5	21:07									
180.0	20:51	21:13								
182.5	20:36	20:58								
185.0	20:21	20:42	21:04							
187.5	20:07	20:28	20:49	21:10						
190.0	19:52	20:13	20:34	20:55						
192.5	19:39	19:59	20:20	20:40	21:01					
195.0	19:25	19:46	20:06	20:26	20:46	21:06				
197.5	19:12	19:32	19:52	20:12	20:32	20:52	21:12			
200.0	18:60	19:19	19:39	19:59	20:18	20:38	20:58			
202.5	18:47	19:07	19:26	19:46	20:05	20:24	20:44	21:03		
205.0	18:35	18:54	19:14	19:33	19:52	20:11	20:30	20:50	21:09	
207.5	18:23	18:42	19:01	19:20	19:39	19:58	20:17	20:36	20:55	
210.0	18:12	18:31	18:49	19:08	19:27	19:46	20:04	20:23	20:42	21:01
212.5	18:01	18:19	18:38	18:56	19:15	19:33	19:52	20:10	20:29	20:47
215.0	17:50	18:08	18:26	18:44	19:03	19:21	19:39	19:58	20:16	20:34
217.5	17:39	17:57	18:15	18:33	18:51	19:09	19:27	19:46	20:04	20:22
220.0	17:28	17:46	18:04	18:22	18:40	18:58	19:16	19:34	19:52	20:09
222.5	17:18	17:36	17:53	18:11	18:29	18:47	19:04	19:22	19:40	19:57
225.0	17:08	17:25	17:43	18:01	18:18	18:36	18:53	19:11	19:28	19:46
227.5	16:58	17:15	17:33	17:50	18:07	18:25	18:42	18:59	19:17	19:34
230.0	16:49	17:06	17:23	17:40	17:57	18:14	18:31	18:48	19:06	19:23
232.5	16:39	16:56	17:13	17:30	17:47	18:04	18:21	18:38	18:55	19:12
235.0	16:30	16:47	17:04	17:20	17:37	17:54	18:11	18:27	18:44	19:01
237.5	16:21	16:38	16:54	17:11	17:27	17:44	18:01	18:17	18:34	18:50
240.0	16:12	16:29	16:45	17:01	17:18	17:34	17:51	18:07	18:23	18:40
242.5	16:04	16:20	16:36	16:52	17:09	17:25	17:41	17:57	18:13	18:30
245.0	15:55	16:11	16:27	16:43	16:59	17:15	17:32	17:48	18:04	18:20
247.5	15:47	16:03	16:19	16:35	16:50	17:06	17:22	17:38	17:54	18:10
250.0	15:39	15:54	16:10	16:26	16:42	16:57	17:13	17:29	17:45	18:01
252.5	15:31	15:46	16:02	16:18	16:33	16:49	17:04	17:20	17:36	17:51
255.0	15:23	15:38	15:54	16:09	16:25	16:40	16:56	17:11	17:27	17:42
257.5	15:15	15:31	15:46	16:01	16:16	16:32	16:47	17:02	17:18	17:33
260.0	15:08	15:23	15:38	15:53	16:08	16:24	16:39	16:54	17:09	17:24
262.5	15:00	15:15	15:30	15:45	16:00	16:15	16:30	16:45	17:00	17:15
265.0	14:53	15:08	15:23	15:38	15:53	16:08	16:22	16:37	16:52	17:07
2675	14:46	15:01	15:16	15:30	15:45	15:60	16:14	16:29	16:44	16:59
270.0	14:39	14:54	15:08	15:23	15:38	15:52	16:07	16:21	16:36	16:50
272.5	14:32	14:47	15:01	15:16	15:30	15:45	15:59	16:14	16:28	16:42
275.0	14:26	14:40	14:54	15:09	15:23	15:37	15:52	16:06	16:20	16:35
277.5	14:19	14:33	14:47	15:02	15:16	15:30	15:44	15:58	16:13	16:27
280.0	14:13	14:27	14:41	14:55	15:09	15:23	15:37	15:51	16:05	16:19
282.5	14:06	14:20	14:34	14:48	15:02	15:16	15:30	15:44	15:58	16:12
285.0	13:60	14:14	14:28	14:41	14:55	15:09	15:23	15:37	15:51	16:04
287.5	13:54	14:08	14:21	14:35	14:49	15:02	15:16	15:30	15:43	15:57
290.0	13:48	14:01	14:15	14:29	14:42	14:56	15:09	15:23	15:37	15:50
292.5	13:42	13:55	14:09	14:22	14:36	14:49	15:03	15:16	15:30	15:43
295.0	13:36	13:49	14:03	14:16	14:30	14:43	14:56	15:10	15:23	15:36
297.5	13:30	13:44	13:57	14:10	14:23	14:37	14:50	15:03	15:16	15:30
300.0	13:25	13:38	13:51	14:04	14:17	14:30	14:44	14:57	15:10	15:23
302.5	13:19	13:32	13:45	13:58	14:11	14:24	14:37	14:50	15:03	15:16
305.0	13:14	13:27	13:40	13:53	14:05	14:18	14:31	14:44	14:57	15:10
307.5	13:08	13:21	13:34	13:47	13:60	14:12	14:25	14:38	14:51	15:04

Weight in Pounds

Cal:	255	260	265	270	275	280	285	290	295	300
310.0	13:03	13:16	13:29	13:41	13:54	14:07	14:19	14:32	14:45	14:58
312.5	12:58	13:11	13:23	13:36	13:48	14:01	14:14	14:26	14:39	14:51
315.0	12:53	13:05	13:18	13:30	13:43	13:55	14:08	14:20	14:33	14:45
317.5	12:48	13:00	13:13	13:25	13:37	13:50	14:02	14:15	14:27	14:39
320.0	12:43	12:55	13:07	13:20	13:32	13:44	13:57	14:09	14:21	14:34
322.5	12:38	12:50	13:02	13:15	13:27	13:39	13:51	14:04	14:16	14:28
325.0	12:33	12:45	12:57	13:10	13:22	13:34	13:46	13:58	14:10	14:22
327.5	12:28	12:41	12:53	13:05	13:17	13:29	13:41	13:53	14:05	14:17
330.0	12:24	12:36	12:48	12:60	13:12	13:24	13:35	13:47	13:59	14:11
332.5	12:19	12:31	12:43	12:55	13:07	13:19	13:30	13:42	13:54	14:06
335.0	12:15	12:27	12:38	12:50	13:02	13:14	13:25	13:37	13:49	14:01
337.5	12:10	12:22	12:34	12:45	12:57	13:09	13:20	13:32	13:44	13:55
340.0	12:06	12:18	12:29	12:41	12:52	13:04	13:15	13:27	13:39	13:50
342.5	12:02	12:13	12:25	12:36	12:48	12:59	13:11	13:22	13:34	13:45
345.0	11:57	12:09	12:20	12:32	12:43	12:54	13:06	13:17	13:29	13:40
347.5	11:53	12:05	12:16	12:27	12:39	12:50	13:01	13:13	13:24	13:35
350.0	11:49	12:00	12:12	12:23	12:34	12:45	12:57	13:08	13:19	13:30
352.5	11:45	11:56	12:07	12:19	12:30	12:41	12:52	13:03	13:14	13:26
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370.0	11:18	11:29	11:39	11:50	12:01	12:11	12:22	12:33	12:43	12:54
372.5	11:14	11:25	11:36	11:46	11:57	12:07	12:18	12:28	12:39	12:50
375.0	11:11	11:21	11:32	11:42	11:53	12:03	12:14	12:24	12:35	12:45
377.5	11:07	11:18	11:28	11:39	11:49	11:59	12:10	12:20	12:31	12:41
380.0	11:04	11:14	11:24	11:35	11:45	11:56	12:06	12:16	12:27	12:37
382.5	11:00	11:11	11:21	11:31	11:41	11:52	12:02	12:12	12:23	12:33
385.0	10:57	11:07	11:17	11:28	11:38	11:48	11:58	12:08	12:19	12:29
387.5	10:54	11:04	11:14	11:24	11:34	11:44	11:55	12:05	12:15	12:25
390:0	10:50	11:00	11:10	11:20	11:31	11:41	11:51	12:01	12:11	12:21
392.5	10:47	10:57	11:07	11:17	11:27	11:37	11:47	11:57	12:07	12:17
395.0	10:44	10:54	11:04	11:14	11:24	11:34	11:43	11:53	12:03	12:13
397.5	10:40	10:50	11:00	11:10	11:20	11:30	11:40	11:50	11:60	12:10
400.0	10:37	10:47	10:57	11:07	11:17	11:27	11:36	11:46	11:56	12:06
402.5	10:34	10:44	10:54	11:04	11:13	11:23	11:33	11:43	11:52	12:02
405.0	10:31	10:41	10:51	11:00	11:10	11:20	11:29	11:39	11:49	11:59
407.5	10:28	10:38	10:47	10:57	11:07	11:16	11:26	11:36	11:45	11:55
410.0	10:25	10:35	10:44	10:54	11:03	11:13	11:23	11:32	11:42	11:52
412.5	10:22	10:32	10:41	10:51	11:00	11:10	11:19	11:29	11:38	11:48
415.0	10:19	10:29	10:38	10:48	10:57	11:07	11:16	11:26	11:35	11:45
417.5	10:16	10:26	10:35	10:45	10:54	11:03	11:13	11:22	11:32	11:41
420.0	10:13	10:23	10:32	10:42	10:51	11:00	11:10	11:19	11:28	11:38
422.5	10:11	10:20	10:29	10:39	10:48	10:57	11:06	11:16	11:25	11:34
425.0	10:08	10:17	10:26	10:36	10:45	10:54	11:03	11:13	11:22	11:31
427.5	10:05	10:14	10:23	10:33	10:42	10:51	11:00	11:09	11:19	11:28
430.0	10:02	10:11	10:21	10:30	10:39	10:48	10:57	11:06	11:16	11:25
432.5	9:60	10:09	10:18	10:27	10:36	10:45	10:54	11:03	11:12	11:22
435.0	9:57	10:06	10:15	10:24	10:33	10:42	10:51	11:00	11:09	11:18
437.5	9:54	10:03	10:12	10:21	10:30	10:39	10:48	10:57	11:06	11:15
440.0	9:52	10:01	10:10	10:18	10:27	10:36	10:45	10:54	11:03	11:12
442.5	9:49	9:58	10:07	10:16	10:25	10:34	10:42	10:51	11:00	11:09

Weight in Pounds

Cal:	255	260	265	270	275	280	285	290	295	300
445.0	9:47	9:55	10:04	10:13	10:22	10:31	10:40	10:48	10:57	11:06
447.5	9:44	9:53	10:02	10:10	10:19	10:28	10:37	10:46	10:54	11:03
450.0	9:41	9:50	9:59	10:08	10:17	10:25	10:34	10:43	10:52	11:00
452.5	9:39	9:48	9:56	10:05	10:14	10:23	10:31	10:40	10:49	10:57
455.0	9:37	9:45	9:54	10:03	10:11	10:20	10:29	10:37	10:46	10:55
457.5	9:34	9:43	9:51	10:00	10:09	10:17	10:26	10:34	10:43	10:52
460.0	9:32	9:40	9:49	9:57	10:06	10:15	10:23	10:32	10:40	10:49
462.5	9:29	9:38	9:46	9:55	10:03	10:12	10:21	10:29	10:38	10:46
465.0	9:27	9:36	9:44	9:53	10:01	10:09	10:18	10:26	10:35	10:43
467.5	9:25	9:33	9:42	9:50	9:58	10:07	10:15	10:24	10:32	10:41
470.0		9:31	9:39	9:48	9:56	10:04	10:13	10:21	10:30	10:38
472.5		9:29	9:37	9:45	9:54	10:02	10:10	10:19	10:27	10:35
475.0		9:26	9:35	9:43	9:51	9:59	10:08	10:16	10:24	10:33
477.5			9:32	9:41	9:49	9:57	10:05	10:14	10:22	10:30
480.0			9:30	9:38	9:46	9:55	10:03	10:11	10:19	10:27
482.5			9:28	9:36	9:44	9:52	10:00	10:09	10:17	10:25
485.0			9:26	9:34	9:42	9:50	9:58	10:06	10:14	10:22
487.5				9:31	9:39	9:48	9:56	10:04	10:12	10:20
490.0				9:29	9:37	9:45	9:53	10:01	10:09	10:17
492.5				9:27	9:35	9:43	9:51	9:59	10:07	10:15
495.0				9:25	9:33	9:41	9:49	9:57	10:05	10:13
497.5					9:31	9:38	9:46	9:54	10:02	10:10
500.0					9:28	9:36	9:44	9:52	9:60	10:08
505.0					9:24	9:32	9:40	9:47	9:55	10:03
507.5						9:30	9:37	9:45	9:53	10:01
510.0						9:28	9:35	9:43	9:51	9:58
512.5						9:25	9:33	9:41	9:49	9:56
515.0							9:31	9:39	9:46	9:54
517.5							9:29	9:37	9:44	9:52
520.0							9:27	9:34	9:42	9:50
522.5							9:25	9:32	9:40	9:47
525.0								9:30	9:38	9:45
527.5								9:28	9:36	9:43
530.0								9:26	9:34	9:41
532.5									9:31	9:39
535.0									9:29	9:37
537.5									9:27	9:35
540.0									9:25	9:33
542.5										9:31
545.0										9:29
547.5										9:27
550.0										9:25

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Development of an Elliptical Trainer Physical Fitness Test

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5d. Project Number:
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6. AUTHORS
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13. SUPPLEMENTARY NOTES

14. ABSTRACT (maximum 200 words)
A cardiovascular fitness test is one element of the U.S. Navy Physical Readiness Test (PRT). This report presents the results of 3 studies that evaluated the potential use of a commercially available elliptical trainer, the CT 9500 HR, for this testing. Study 1: Different machines produced virtually identical calorie expenditure estimates when a test subject performed a series of bouts at the same resistance and stride rate on each machine. Study 2: The calorie expenditure reported by the CT 9500 HR during 12-minute exercise bouts was highly correlated ($r = .900$) with the energy expenditure measured by open-circuit spirometry (OCS); the machine report was ~34 Kcal higher than the OCS estimate. Study 3: CT 9500 HR calorie estimates recorded during 12-minute exercise bouts accurately predicted run times (women, $r = .890$; men, $r = .900$). The slope of the regression of run time on CT 9500 HR calories was the same for men and women, but the intercept was higher for women than for men. Potential PRT standards for the CT 9500 HR were identified by using these equations to match CT 9500 HR performance to current PRT standards for the 1.5-mile run for men and women.

15. SUBJECT TERMS
Physical Readiness Test, cardiovascular fitness, run tests, elliptical trainer

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